Wireless Technologies & Networks

Part 2. Wireless LANs. IEEE 802.11

Recommended References

A. Tanenbaum, Computer networks. 3rd edition, Prentice Hall, 1996

T.Imielinski, H. Korth “Mobile Computing”, Kluwer Academic publishers, 1996

G. Forman & J. Zahorjan “The challenges of mobile computing”, IEEE Computer, April 1994, pp.38-47

J. Mikkonen, “Wireless ATM overview”, http://www.tele.pw.edu.pl/Pl-iso/~kwrona/watm/wireless.html

Wireless LAN Alliance – WLANA, http://www.wlana.com

Wireless 5GHz Industry Meetings (Redmond and Amsterdam) http://www.microsoft.com/hwdev/wireless/presentations/wireless5ghz.zip

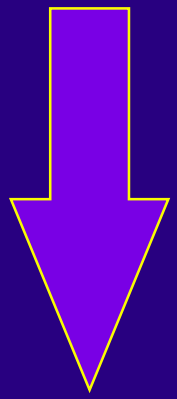
Microsoft Wireless Technology, http://www.microsoft.com/hwdev/wireless/

Aironet/Cisco Training materials

Wireless LANs: What we'll discuss ?

- Introduction & background
- IEEE 802.11
- Aironet/Cisco wireless LANs
- Demo
- Current infrastructure
- Future/target infrastructure

The wireless data challenge

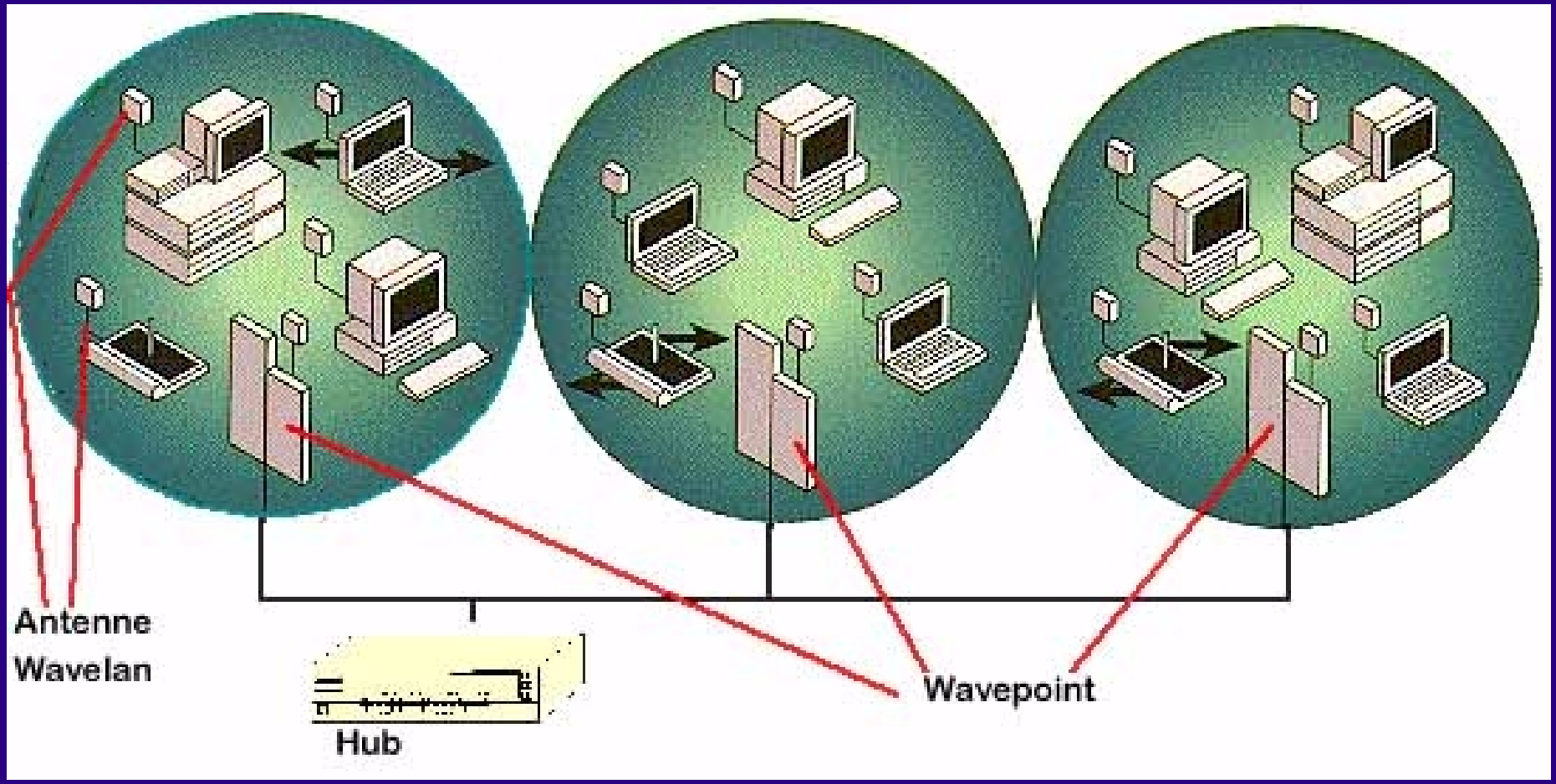


To enable people to communicate/compute effortlessly, where they want, when they want, without "Wires"

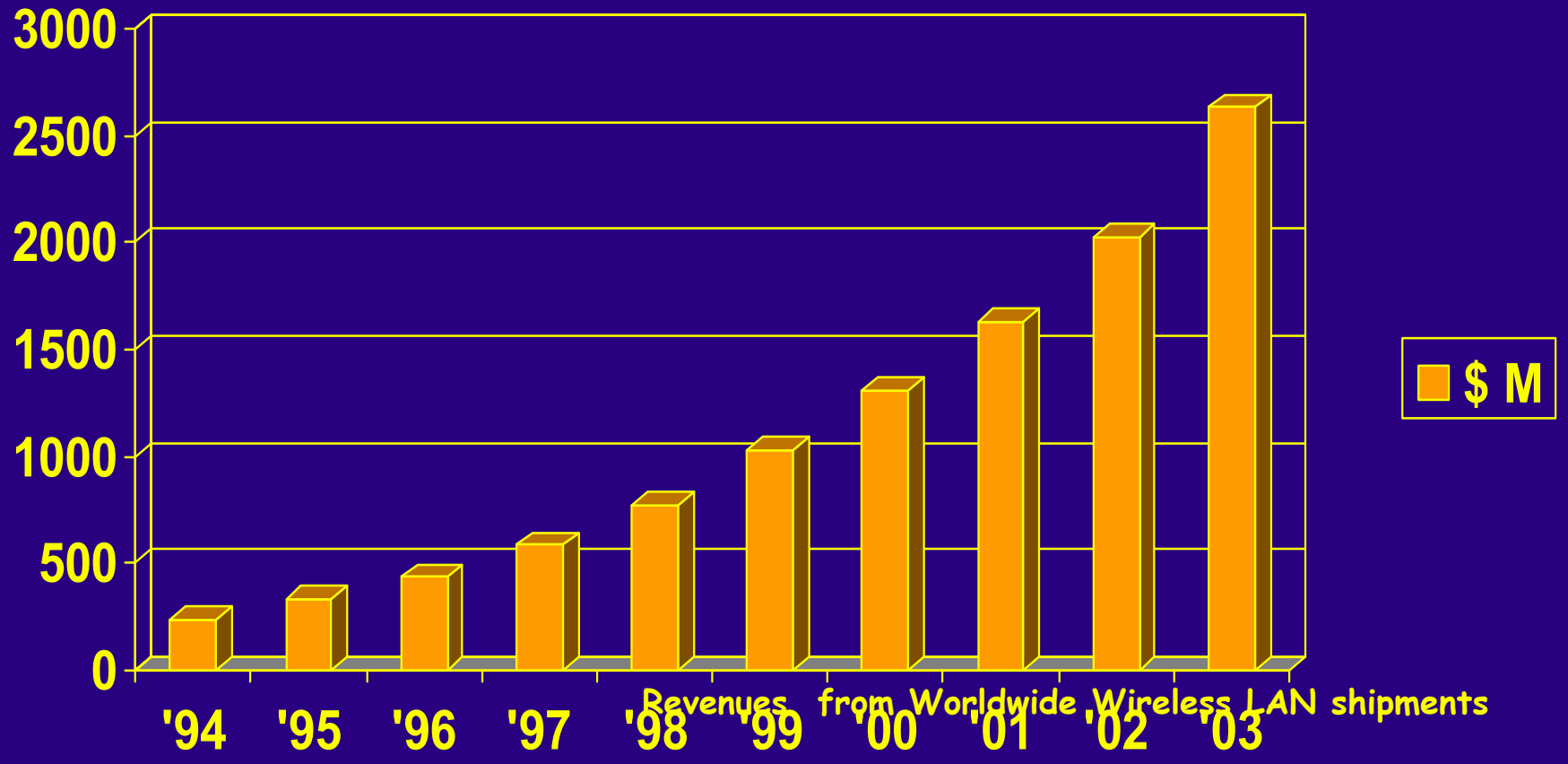
Wireless LANs

- The work on radio-based computer networks goes back to the early seventies and the work on Aloha network.
- Wireless LANS are providing data rates typically 2 orders of magnitude higher than outdoor radio. Thus, data rates exceeding 1 Mb/s are quite common.
- WaveLAN provides peer-to-peer communication in 902-928 MHZ (in the US) and uses direct sequence spreading with the CSMA/CA (carrier sense, multiple acess, with collision avoidance) protocol.
- Standards such as IEEE 802.11 are being developed in the US and in Europe. In general, the goal is to provide data rates exceeding 1 Mb/s and also to support architectures with infrastructure (base stations) as well as ad-hoc architectures where the terminals communicate directly with each other (peer to peer) without the mediation of a fixed base station.

Architecture of a Wireless LAN



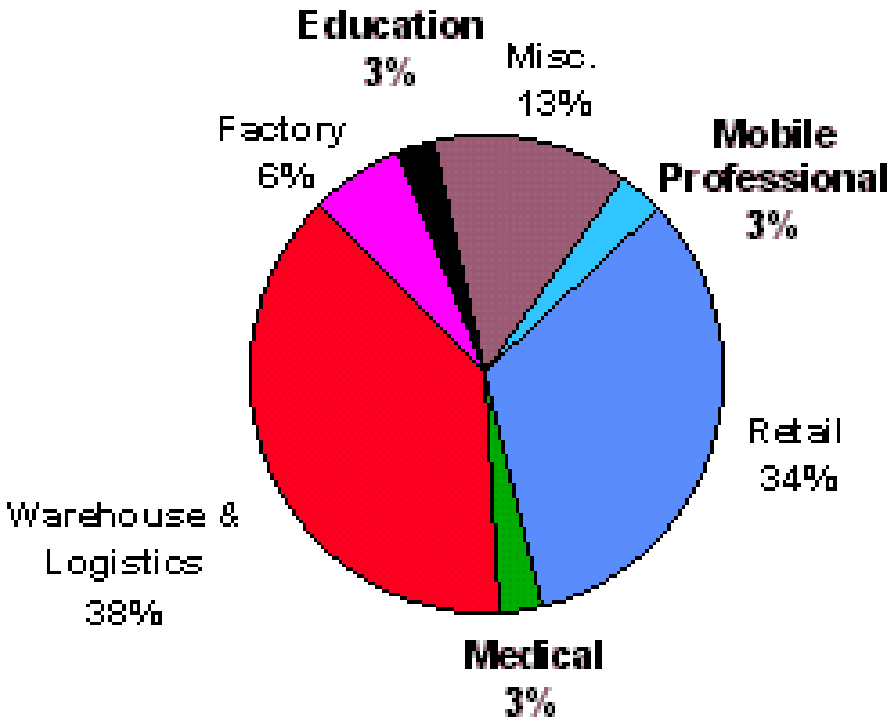
Wireless will replace wired?



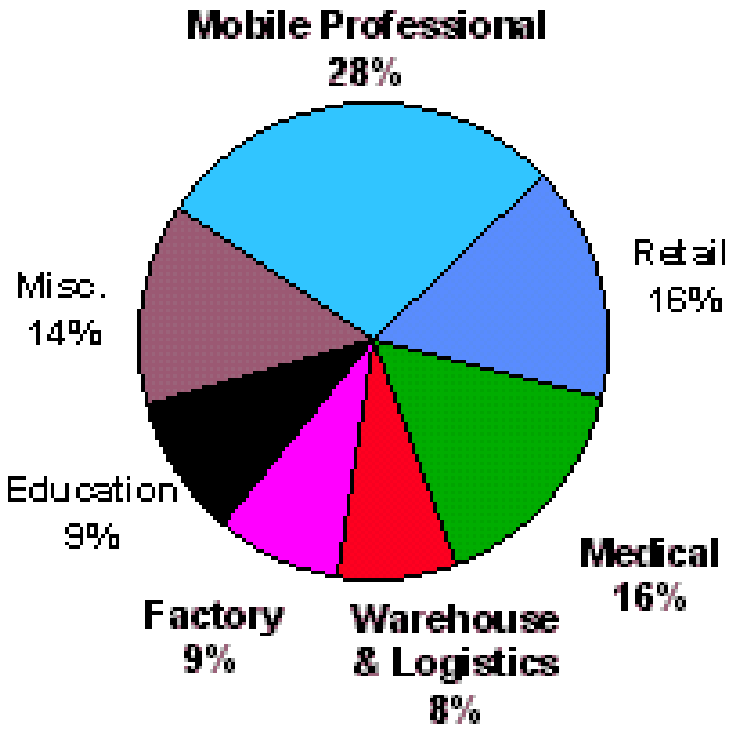
WLAN APPLICATIONS

	1995 (%) 331,000 LANs	2000 (%) 4.1 million
Education	3	9
Factory	6	9
Warehouse	38	8
Medical	3	16
Retail	34	16
Mobile Professional	3	28
Miscellaneous	13	14

W-LAN APPLICATIONS



1995
331,000 LANs



2000
4.1 million LANs

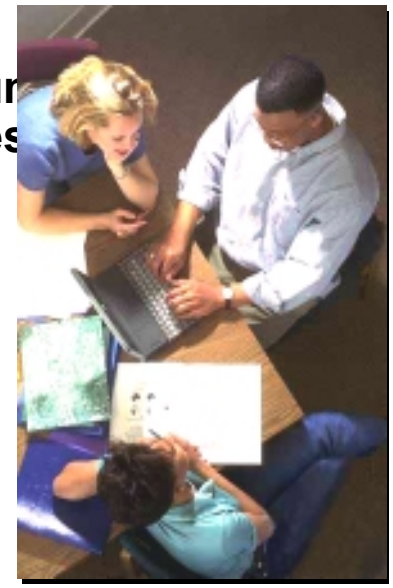
Source: Giga Information Group

RESEARCH ISSUES

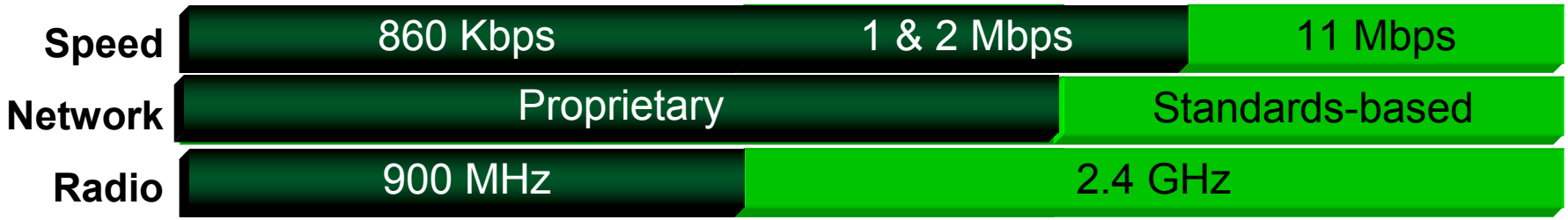
- Internetworking of fixed and mobile networks
- Naming, locating and load balancing techniques for mobile clients and servers
- Traffic monitoring and control mechanisms to maintain
- Quality of Service (Qos)
- Power management

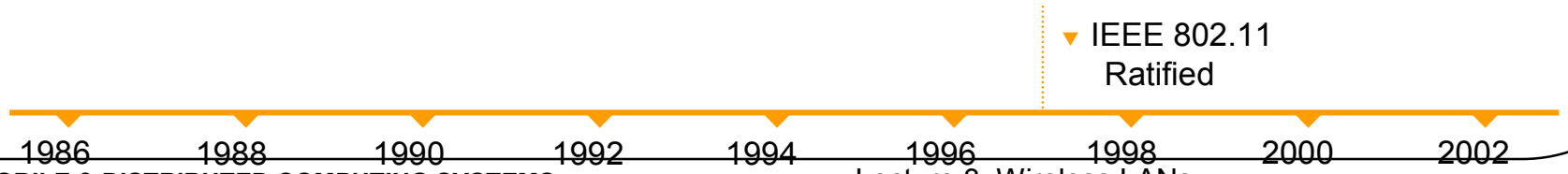
WLAN Evolution: 2000

- Small and Mediur Sized Businesses
- Small Office / Home Office



- Home Networking

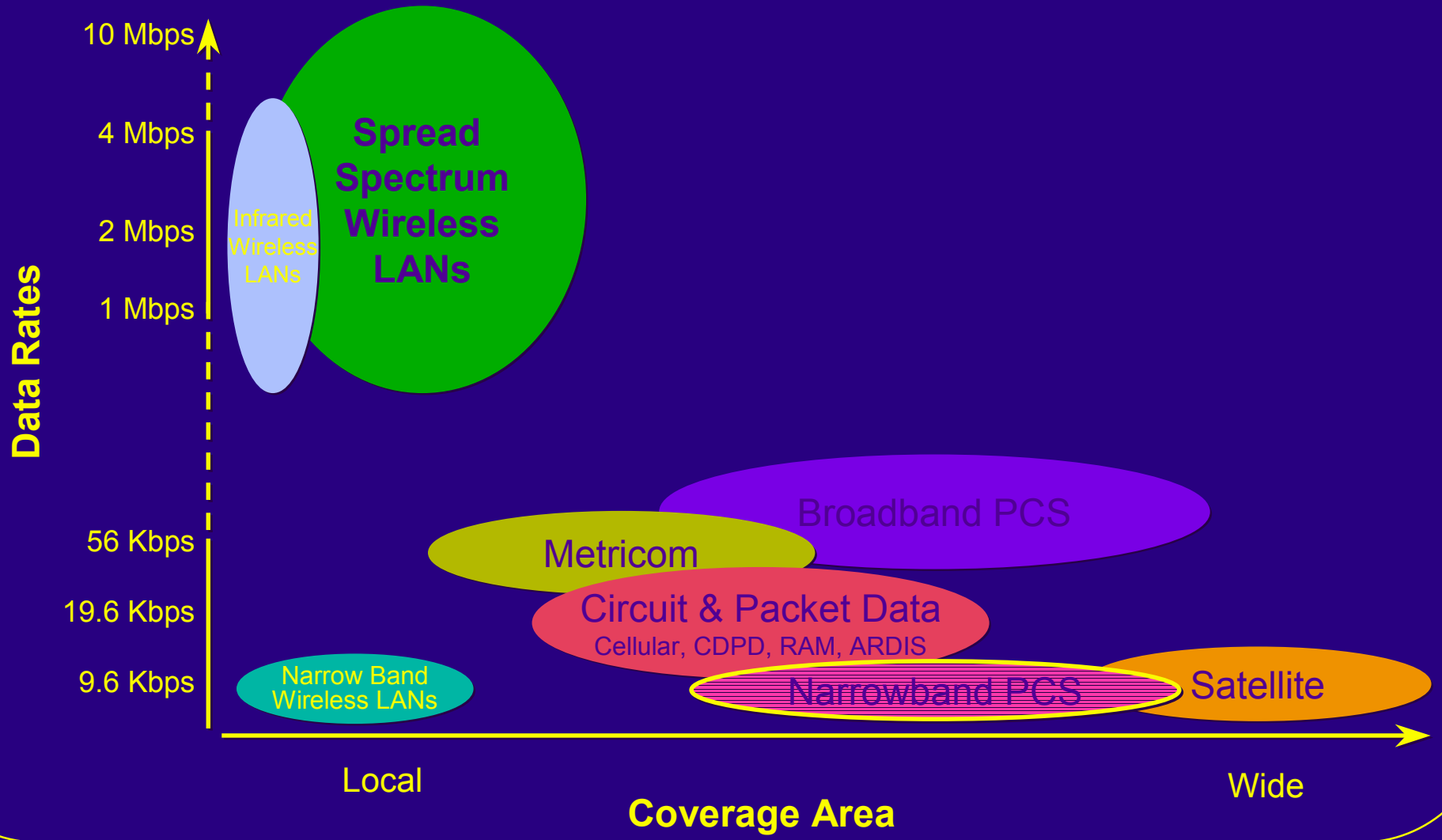




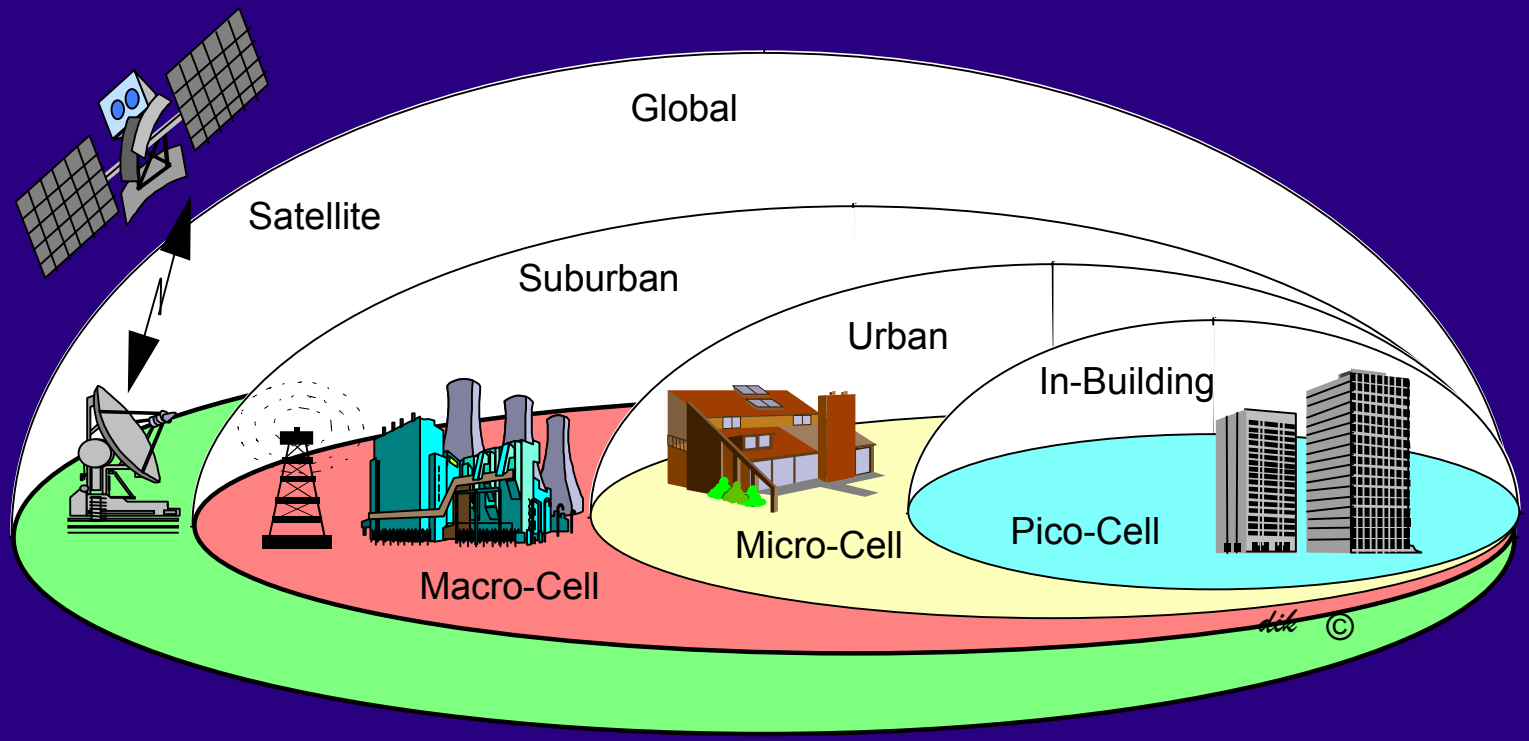
Wireless LAN Applications

- LAN extension: hospitals, factory floors, branch offices, offices with wiring difficulties
- Inter-LAN bridges: Cross-building point-to-point connection, high speed distance access.
- Ad-hoc networking: conference registrations, campaign headquarters, military camps
- Nomadic access: laptop to printer access
- Infopad: fusion of computer and communication in ship boards, research labs
- Campus area networks (CAN): wireless class rooms, wireless Internet access
- Body LAN: for soldiers in the battlefield

Wireless Data Networks



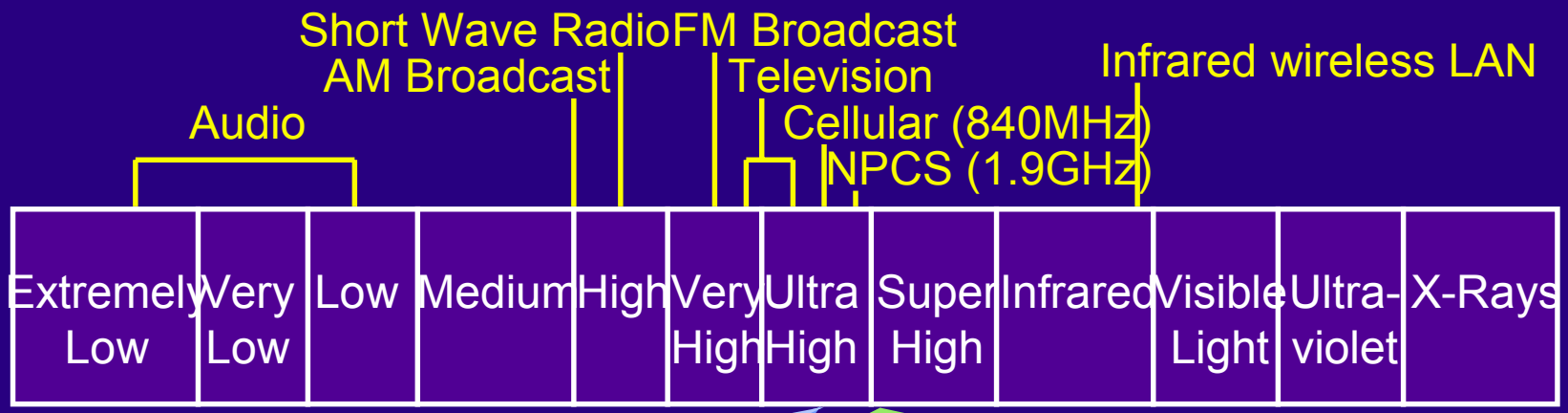
Global Wireless Infrastructure



Wireless problems

- Typically slower than wired networks
- Higher transmission bit error rates (BER)
- Uncontrolled population
- Difficult to ensure Quality of Service (QoS)
- Asymmetric bandwidth
- Limited communication bandwidth aggravates the problem of limited battery life
- Security
- Relative cost !!!

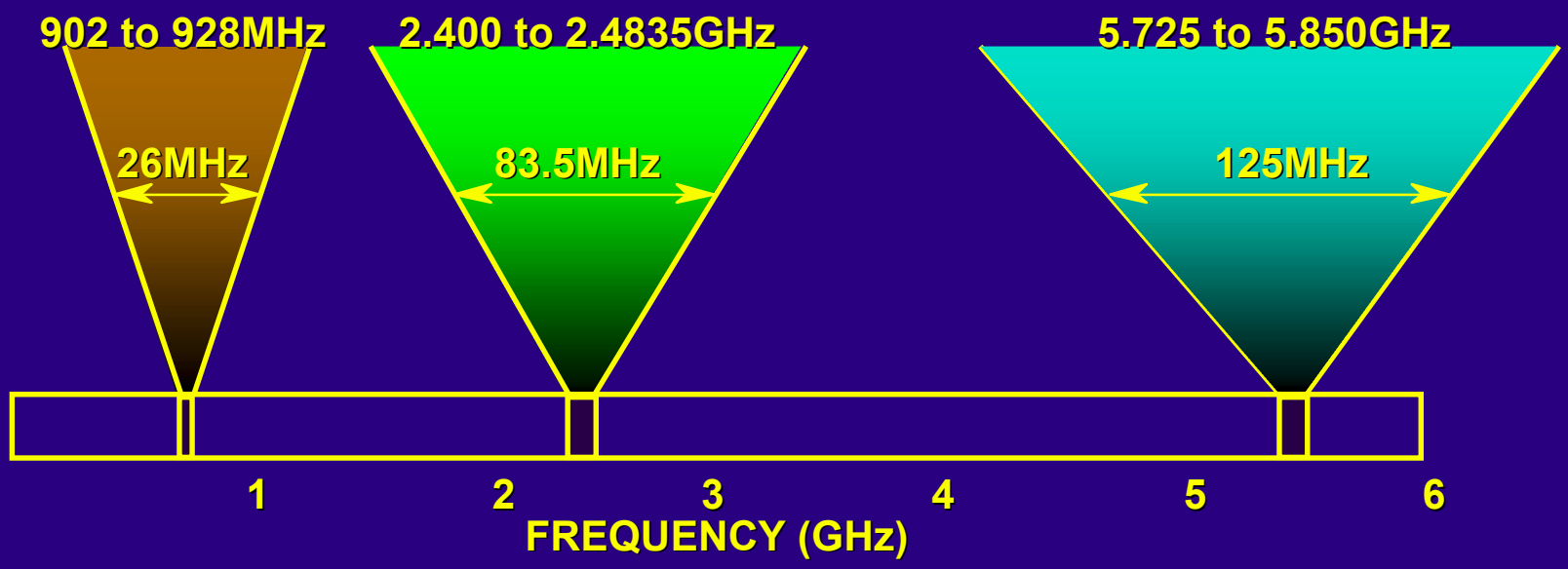
ISM Unlicensed Frequency Bands



902 - 928 MHz
26 MHz

2.4 - 2.4835 GHz
83.5 MHz
(IEEE 802.11)

Industrial, Scientific and Medical (ISM) Bands



- SPREAD SPECTRUM ALLOWED TO MINIMIZE INTERFERENCE
- 2.4GHz ISM BAND
  - More Bandwidth to Support Higher Data Rates and Number of Channels
  - Available Worldwide
  - Good Balance of Equipment Performance and Cost Compared with 5.725GHz Band
  - IEEE 802.11 Global WLAN Standard

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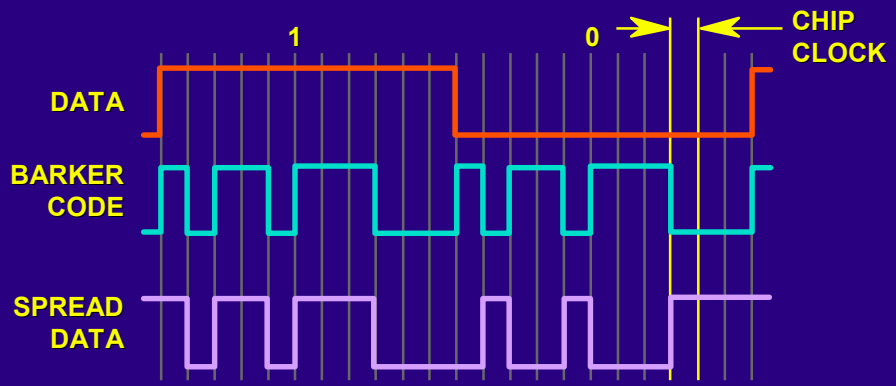
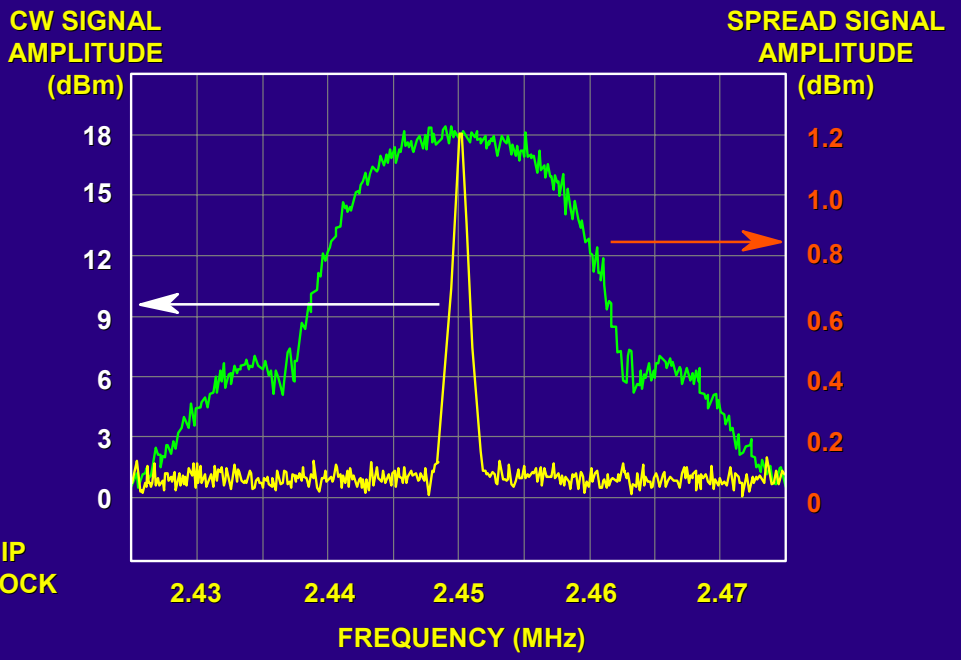
Direct Sequence Spread Spectrum

- DATA SIGNAL SPREAD BY A PN CODE
- PROPERTIES OF PN CODE
- CHIP RATE
- DS PROCESSING GAIN

$$G_P\ (dB) = 10LOG\ (\frac{CHIP\ RATE}{DATA\ RATE})$$

- PN CORRELATION AT RECEIVER
- PSK DATA MODULATION





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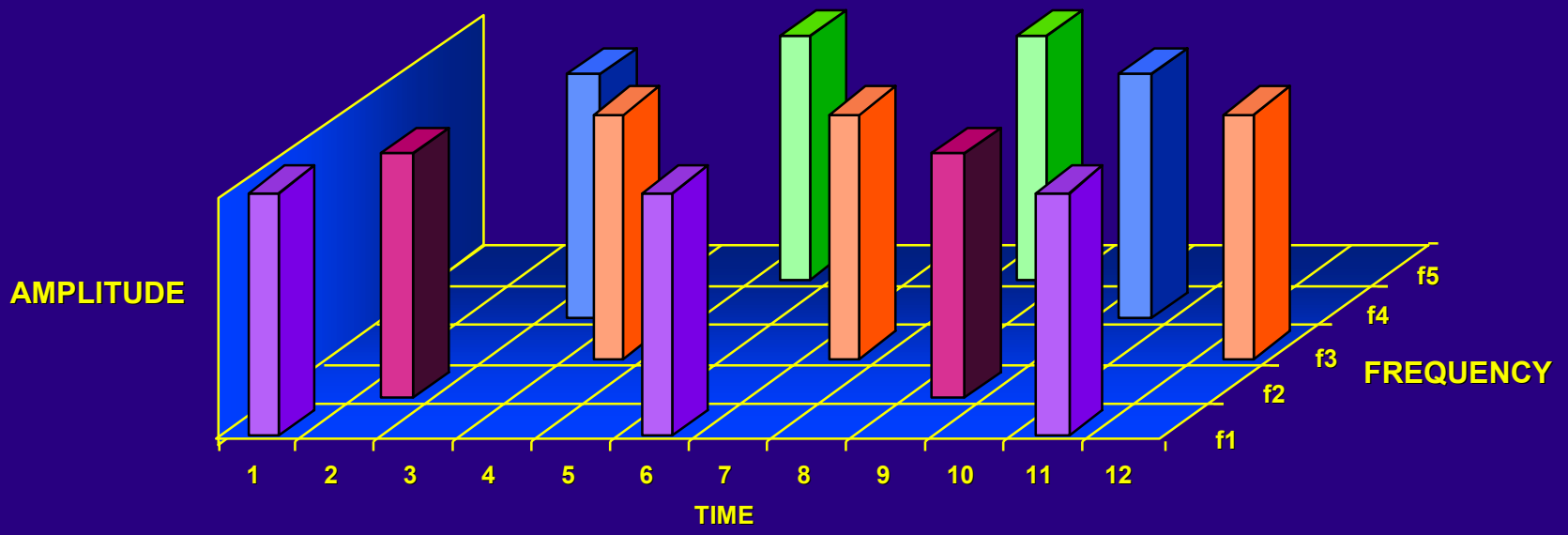
Frequency Hopping Spread Spectrum



- FSK DATA MODULATION
- PERIODIC CHANGES IN THE CARRIER FREQUENCY SPREADS THE SIGNAL
- CARRIER FREQUENCY CHANGES AT A SPECIFIED HOP RATE
- CARRIER FREQUENCY HOPS AFTER A PRESCRIBED TIME
- TOTAL SYSTEM BANDWIDTH INCLUDES ALL OF THE CHANNEL FREQUENCIES USED IN HOPPING

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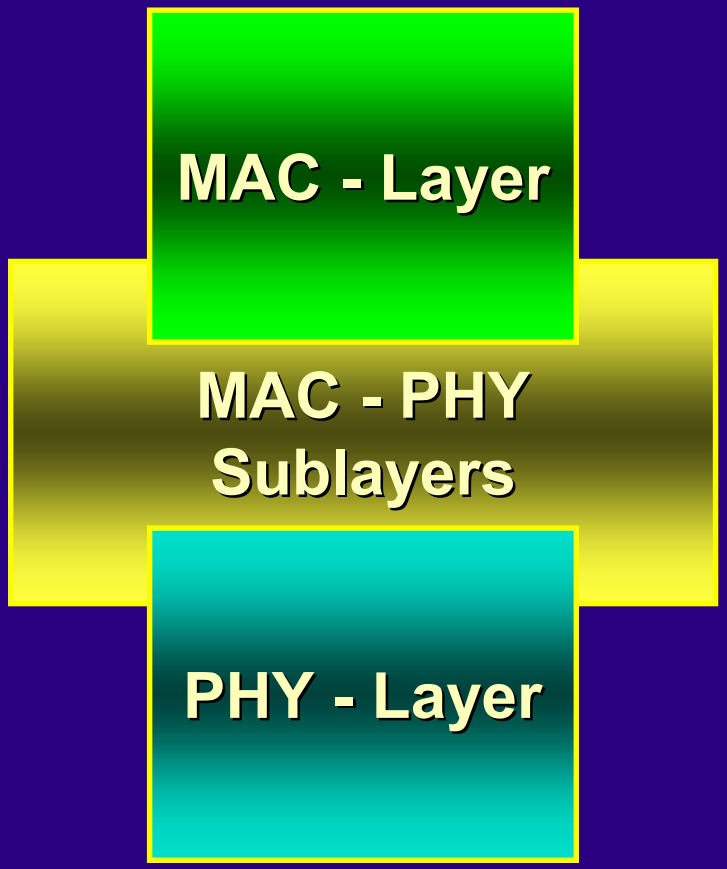
802.11 Protocol Layers



Media Access Control Layer

PROTOCOL AND PHYSICAL LAYER MANAGEMENT

MAC-PHY Sublayers

CONFIGURE DATA FRAMES AND PREAMBLES FOR TRANSMIT AND RECEIVE MODE

Physical Layer

RADIO TRANSMISSION MEDIA FOR EITHER DSSS, FHSS OR INFRARED

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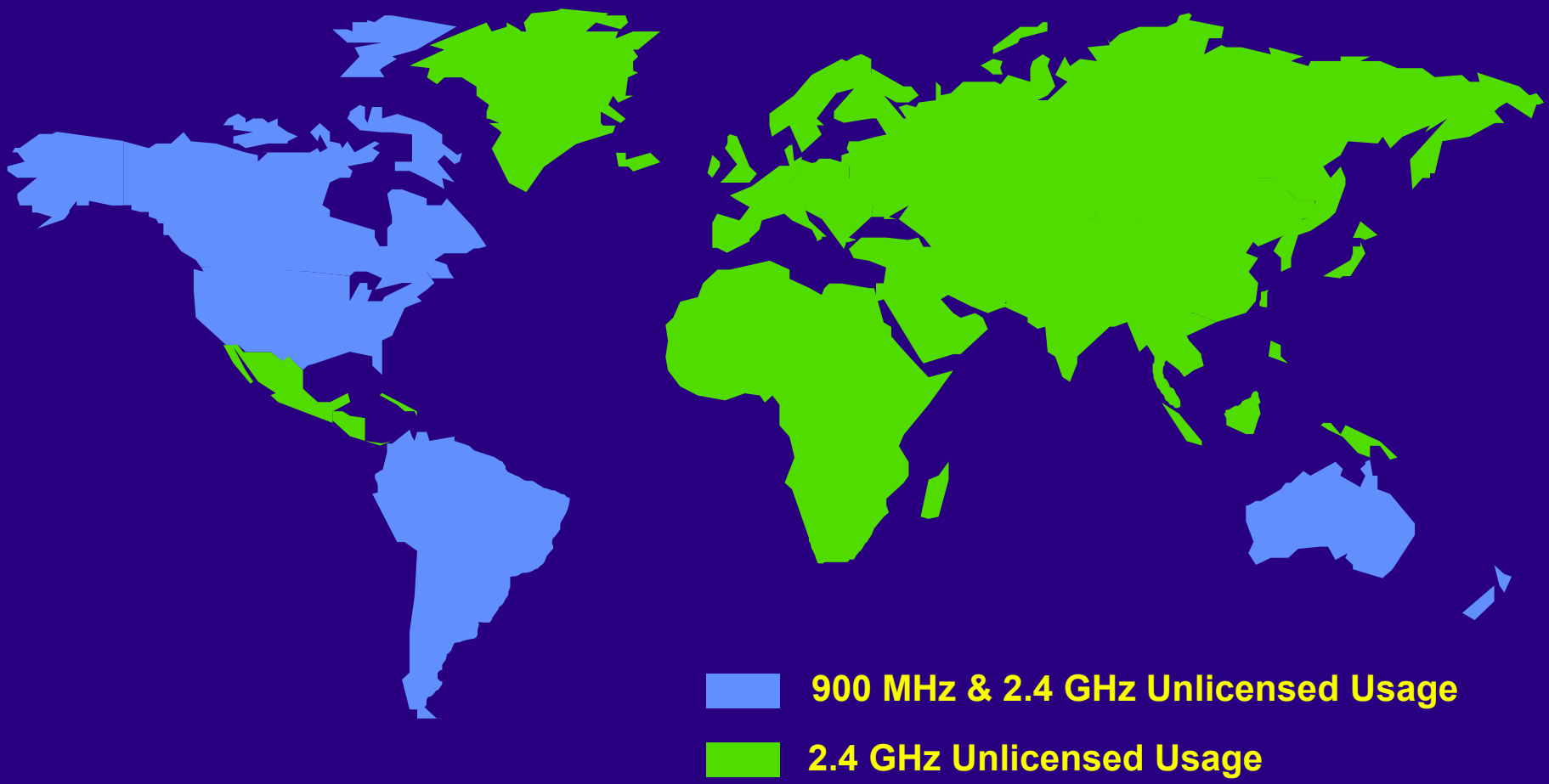
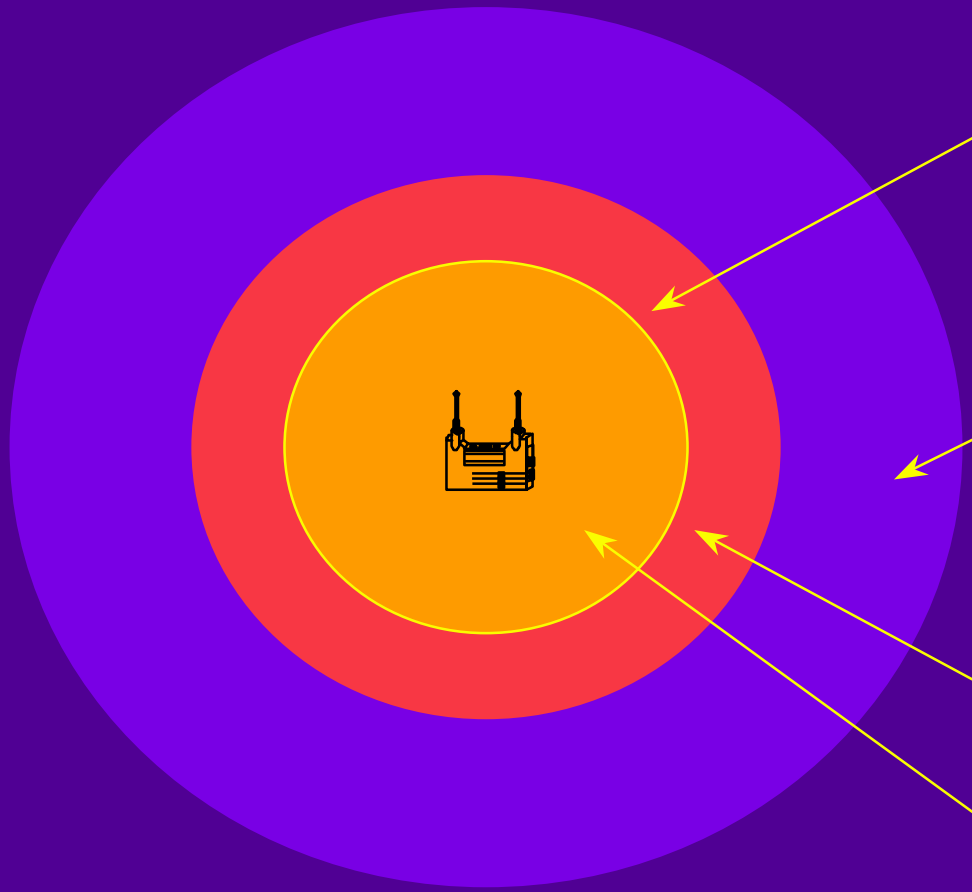
Global RF Regulations



Access Point Coverage



2 Mbps FHSS
175 feet radius

2 Mbps DSSS
1 Mbps FHSS
350 feet radius

5.5 Mbps DSSS
175 feet radius

11 Mbps DSSS
125 feet radius

IEEE 802.11 Standard

- IEEE 802.11 became a standard in July 1997
- Three technologies defined:
  - FHSS - 1 Mbps and 2 Mbps
  - DSSS – 2+ Mbps
  - Infrared
- 802.11 defines a high-performance radio
- 802.11 promises true vendor interoperability (over the air)
- Every vendor must have a viable 802.11 product strategy
  - 802.11 compliant products
  - Current proprietary products

Glossary of 802.11 Wireless Terms

- Station (STA): A computer or device with a wireless network interface.
- Access Point (AP): Device used to bridge the wireless-wired boundary, or to increase distance as a wireless packet repeater.
- Ad Hoc Network: A temporary one made up of stations in mutual range.
- Infrastructure Network: One with one or more Access Points.
- Channel: A radio frequency band, or Infrared, used for shared communication.
- Basic Service Set (BSS): A set of stations communicating wirelessly on the same channel in the same area, Ad Hoc or Infrastructure.
- Extended Service Set (ESS): A set BSSs and wired LANs with Access Points that appear as a single logical BSS.

Glossary of 802.11 Wireless Terms, cont.

- BSSID & ESSID: Data fields identifying station's BSS & ESS.
- Clear Channel Assessment (CCA): A station function used to determine when it is OK to transmit.
- Association: A function that maps a station to an Access Point.
- MAC Service Data Unit (MSDU): Data Frame passed between user & MAC.
- MAC Protocol Data Unit (MPDU): Data Frame passed between MAC & PHY.
- PLCP Packet (PLCP_PDU): Data Packet passed from PHY to PHY over the Wireless Medium.

Overview, IEEE 802, and 802.11 Working Group

- IEEE Project 802 charter:
  - Local & Metropolitan Area Networks
  - 1Mb/s to 100Mb/s and higher
  - 2 lower layers of 7 Layer OSI Reference Model
- IEEE 802.11 Working Group scope:
  - Wireless connectivity for fixed, portable and moving stations within a limited area
  - Appear to higher layers (LLC) the same as existing 802 standards
    - ⇒ Transparent support of mobility (mobility across router ports is being address by a higher layer committee)

IEEE 802.11a Current Status

- Uses same MAC as IEEE 802.11b
  - 802.11a is a PHY extension only
- 5 GHz PHY formally adopted in Fall '99
  - mandatory rates to 24 Mbps, optional rates to 54 Mbps
  - PHY is nearly identical to HiperLAN2 (result of cooperation of both groups)
- Products
  - Expected rollout in late '00 or early '01
- WECA position
  - Support IEEE802.11a @ 5 GHz
  - Support efforts toward single global standard

IEEE 802.11x Enhancements

- Task Group E
  - QoS
    - ⇒ MAC enhancements to support time bounded services
      - classes of service
      - prioritization
  - Security
    - ⇒ standardize 128 bit encryption
    - ⇒ key management
    - ⇒ enhanced authentication algorithm
- Task Group F
  - Roaming & Load Balancing
- Finalize enhancements late ‘00/ early ‘01
    - ⇒ first products very shortly thereafter

2.4GHz Protocol Issues

One reason for the threats at 2.4 GHz is protocols that are incompatible and can cause significant interference if run simultaneously in the same location.

2.4 GHz protocols - Independently developed to support specific usage models

	802.11b	HomeRF	Bluetooth
Coded data rates	11 Mbps	1.6 Mbps	1.0 Mbps
End-user throughput	5.5 Mbps	0.8 Mbps	0.7 Mbps
Multimedia support	No	Audio	Audio
Low-power operation	No	No	Yes
Range	150ft.	150ft.	30ft.
True network	Yes	Yes	No
Supports roaming	Yes	No	No
Cost	High	Medium	Low

2.4GHz / 5GHz Industry Issues

The entire WLAN industry loses if we let the 5 GHz band devolve into the same situation as the 2.4 GHz band.

- 2.4 GHz is being perceived as a band that is overcrowded with incompatible protocols and interfering devices and will result in dissatisfied WLAN users
- At 5 GHz
  - Neither Hiperlan2 or 802.11a adequately addresses the issue of low cost, low power, low speed devices
  - Hiperlan2 and 802.11a have incompatible MAC/data link control (DLC) layers

The Industry Opportunity - A 5GHz Unified Protocol (5-UP)

5-UP is a concept for a protocol extension that works with 802.11a and Hiperlan2 to improve scaleability, interoperability, and marketability of 5GHz WLANs.

A single, compatible, evolutionary extension to both Hiperlan 2 and 802.11a that:

- Supports and extends both existing WLAN standards, and does not impede the delivery of first generation products based on those standards
- Allows for scalability in power, price and performance - 125 kbps through high rates (~100 Mbps)
- Allows devices with the extension to work in either an Hiperlan 2 or an 802.11a network

Information Anytime, Anywhere

Connecting Everything

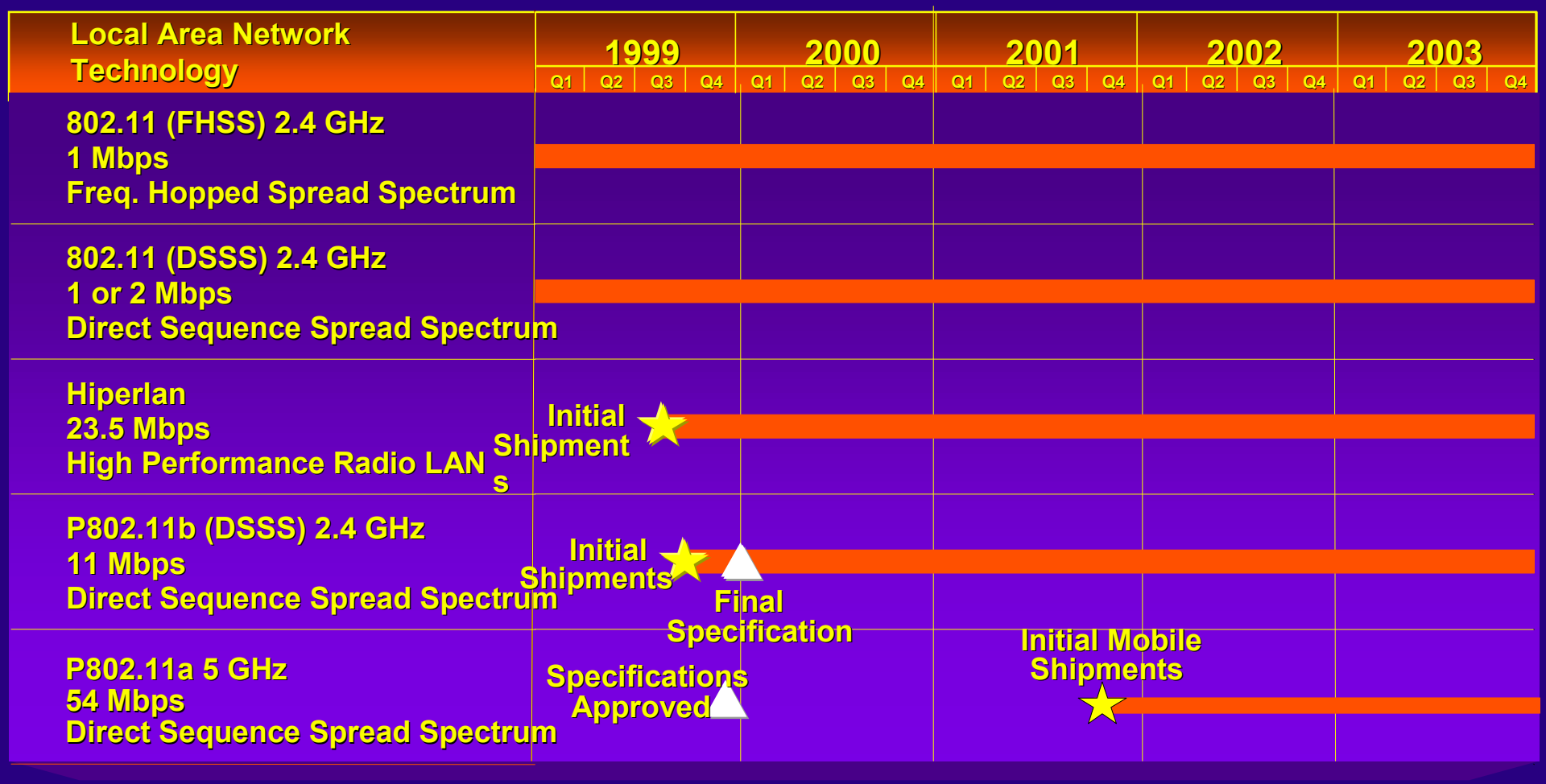
Microsoft Wireless Technology

Windows 98
Windows 2000

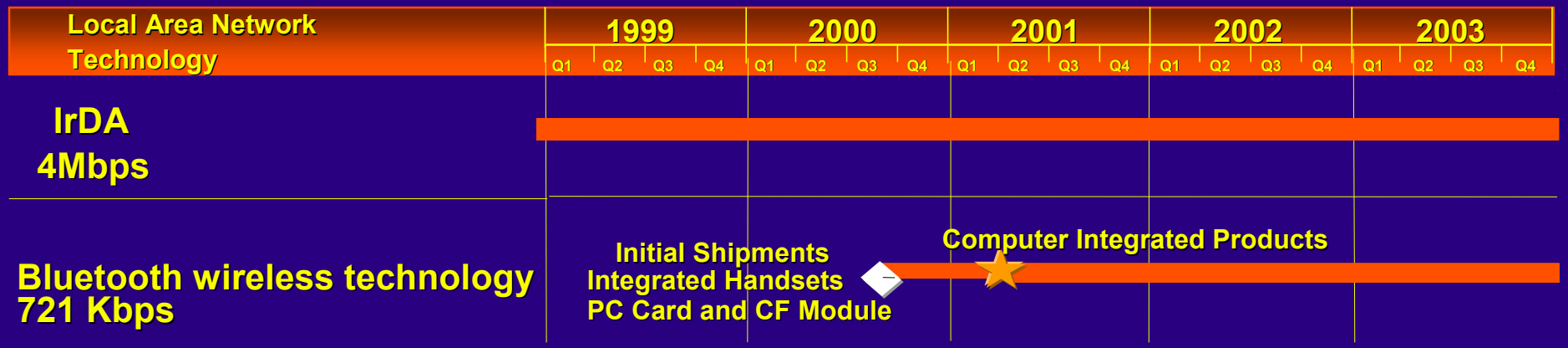
Windows NT® Embedded
Windows CE

Micro-browser
Smart Card for Windows

Local-Area Wireless



Personal Area Wireless



Scenarios

- Adhoc
- Home
- Small business
- Enterprise
- ISP

Ad Hoc Networks

Many diverse devices to be connected

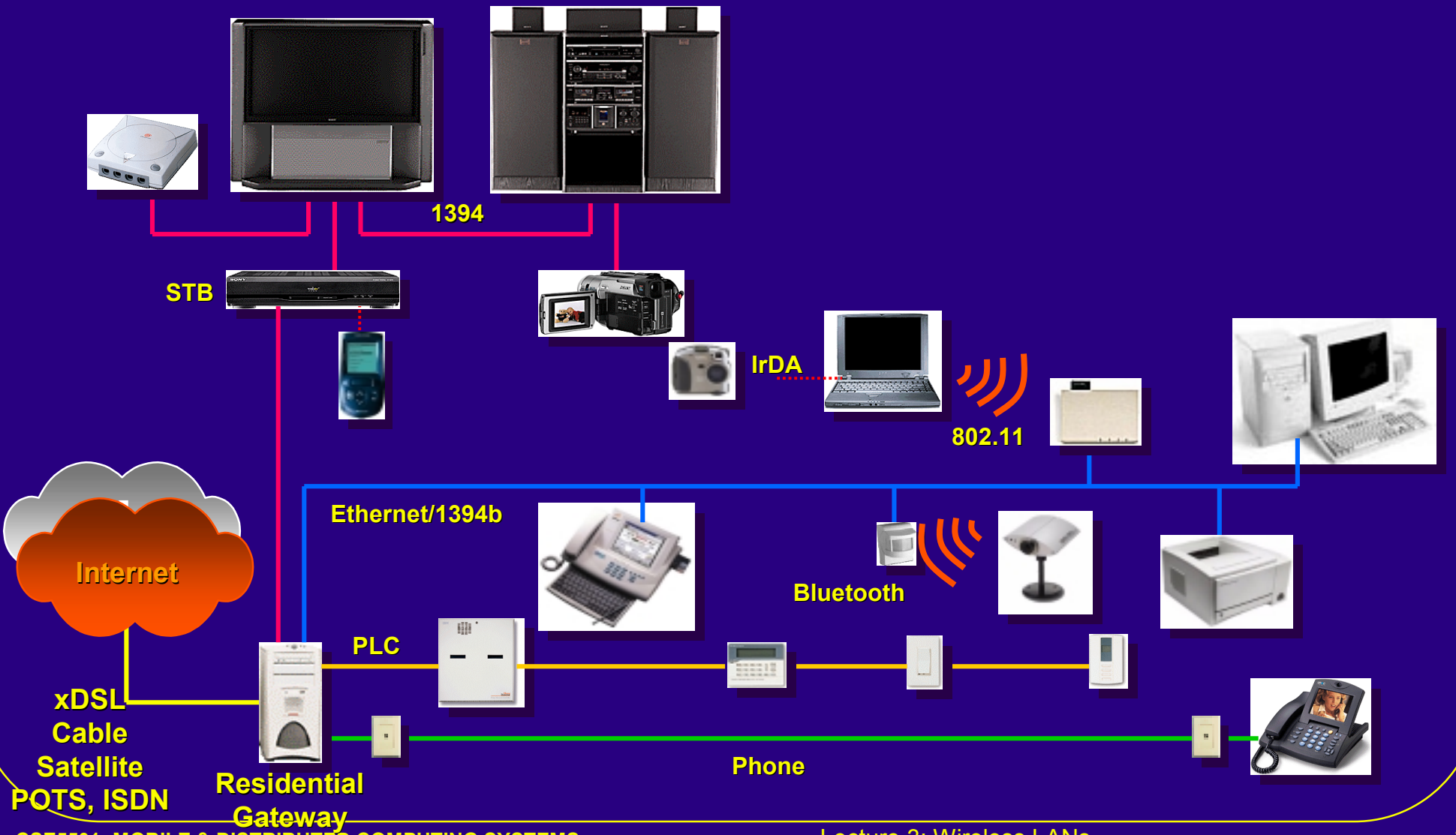
Desktops, Notebooks

TVs, games

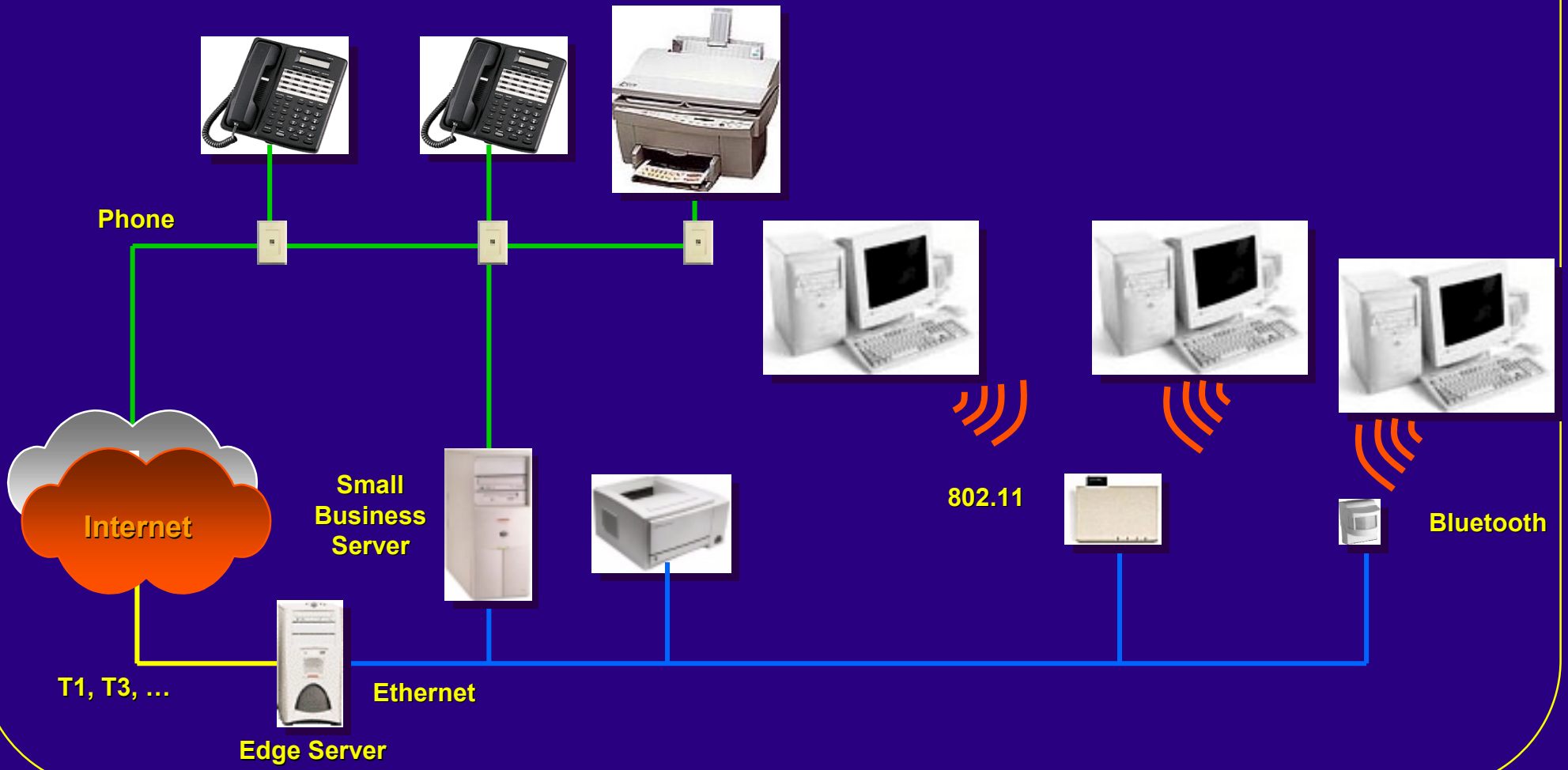
Books, tablets, handheld PCs

Phones, Pagers PC companions

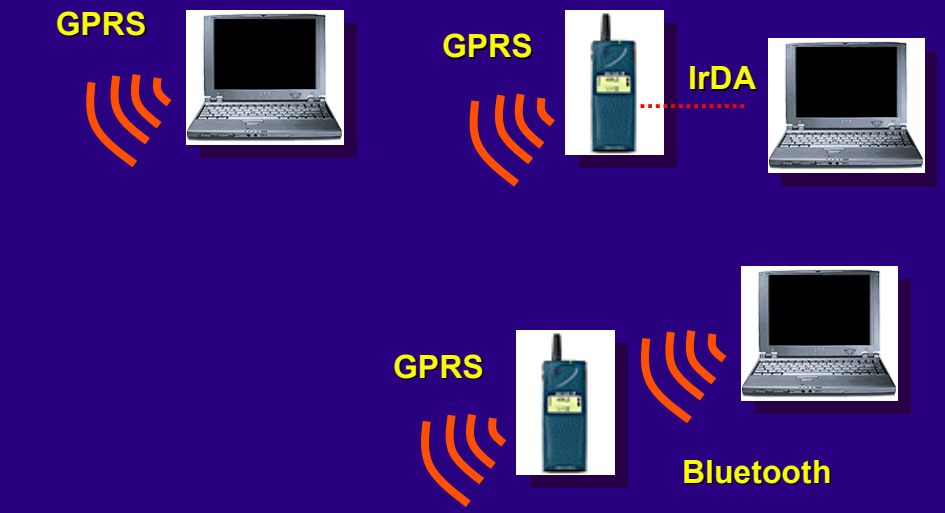
A Connected Home



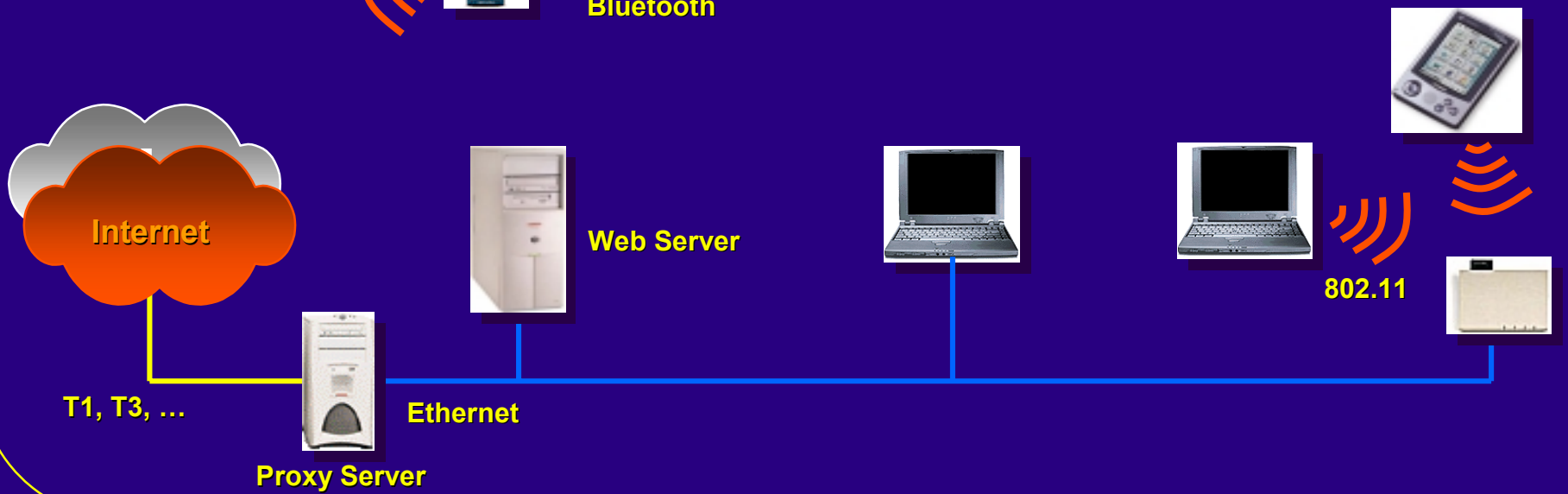
A Connected Small Office



Enterprise



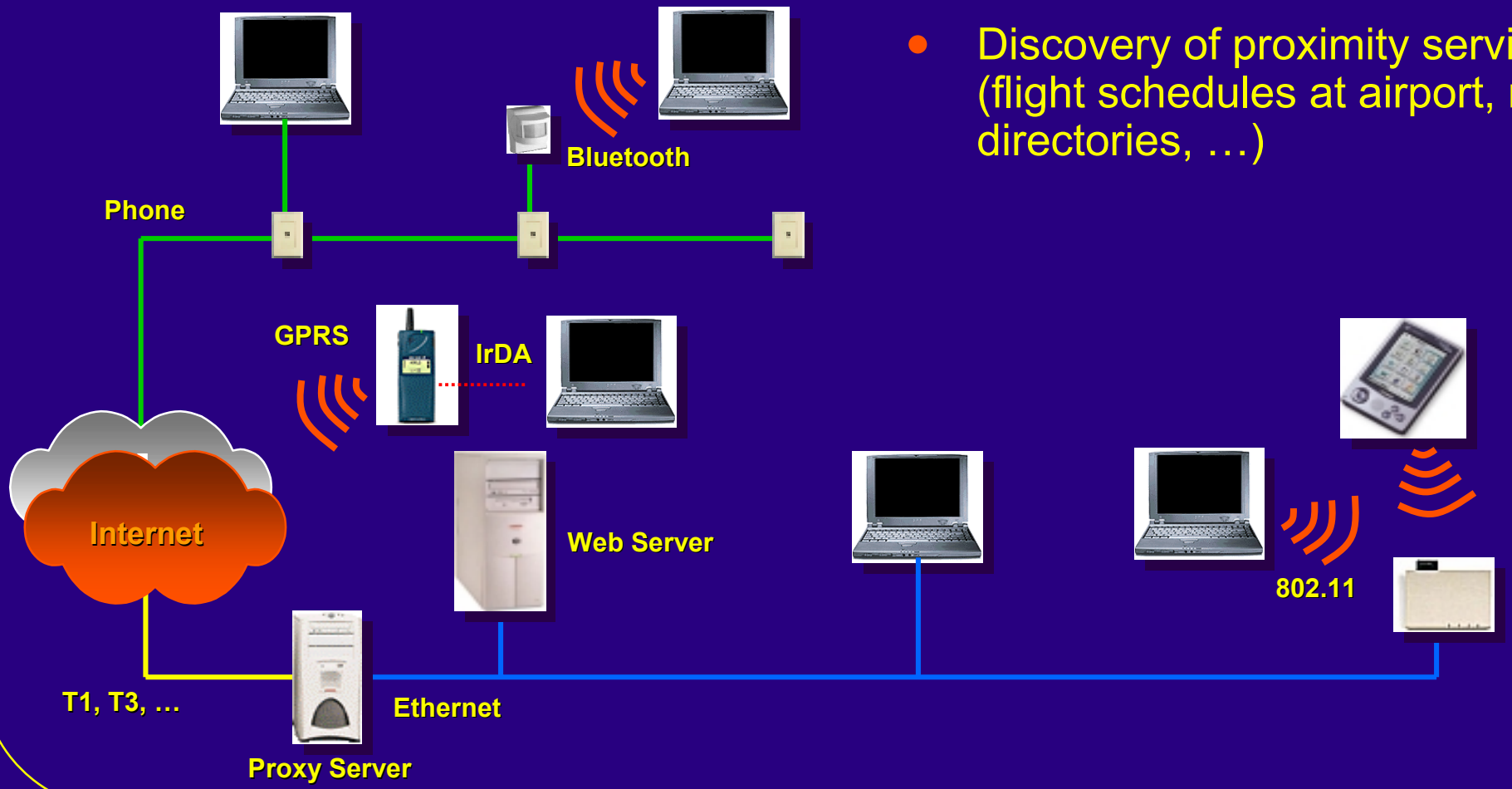
- Information at your fingertips
  - At meetings, in the office, on the road
  - Reliable, secure, multimedia LAN



Enterprise

- End-user can access the enterprise wireless network transparently over a secure connection
  - The network administrator has control over which users have access to the enterprise wireless LAN
- Enterprise can offer its employees access via ISPs which outsource their authentication to the enterprise
  - End-user has IP connectivity as soon as a CDPD or a GPRS modem is plugged in
  - Make cellphones an always connected Internet access point using GPRS
- End-User can use Netmeeting with wireless LAN, when out of range of LAN can continue to conference via IP connected cellphone

An ISP Connected Public Space



- Discovery of proximity services (flight schedules at airport, mall directories, …)

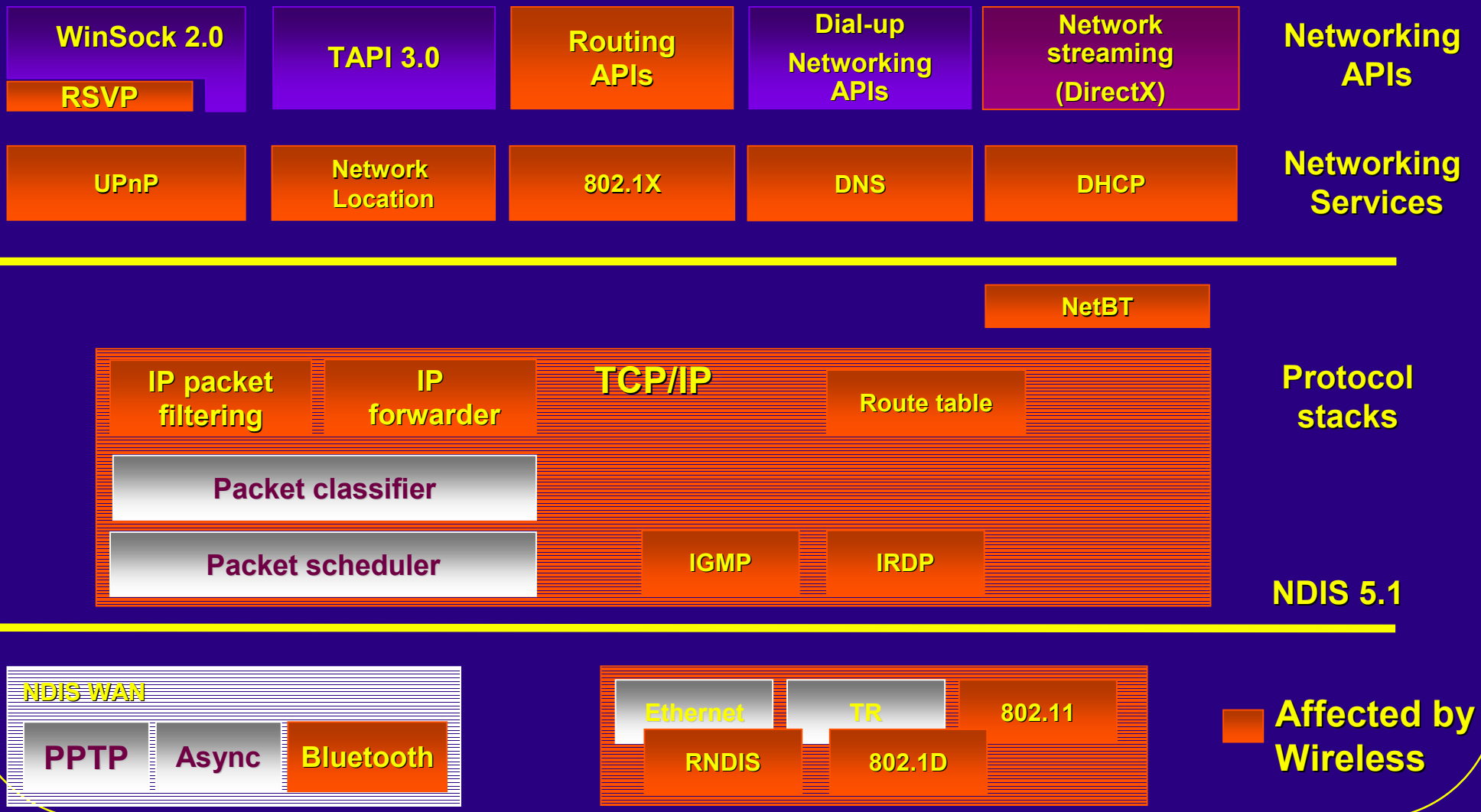
ISP

- Need mixed technologies
  - Higher speed in hot spots, e.g., 802.11
- Need authentication so ISPs can charge
- Allow ISPs to integrate into existing systems
  - Allows ISP roaming agreements
    - ⇒ Same as outsource dial
- Need to be able to provision unauthenticated users

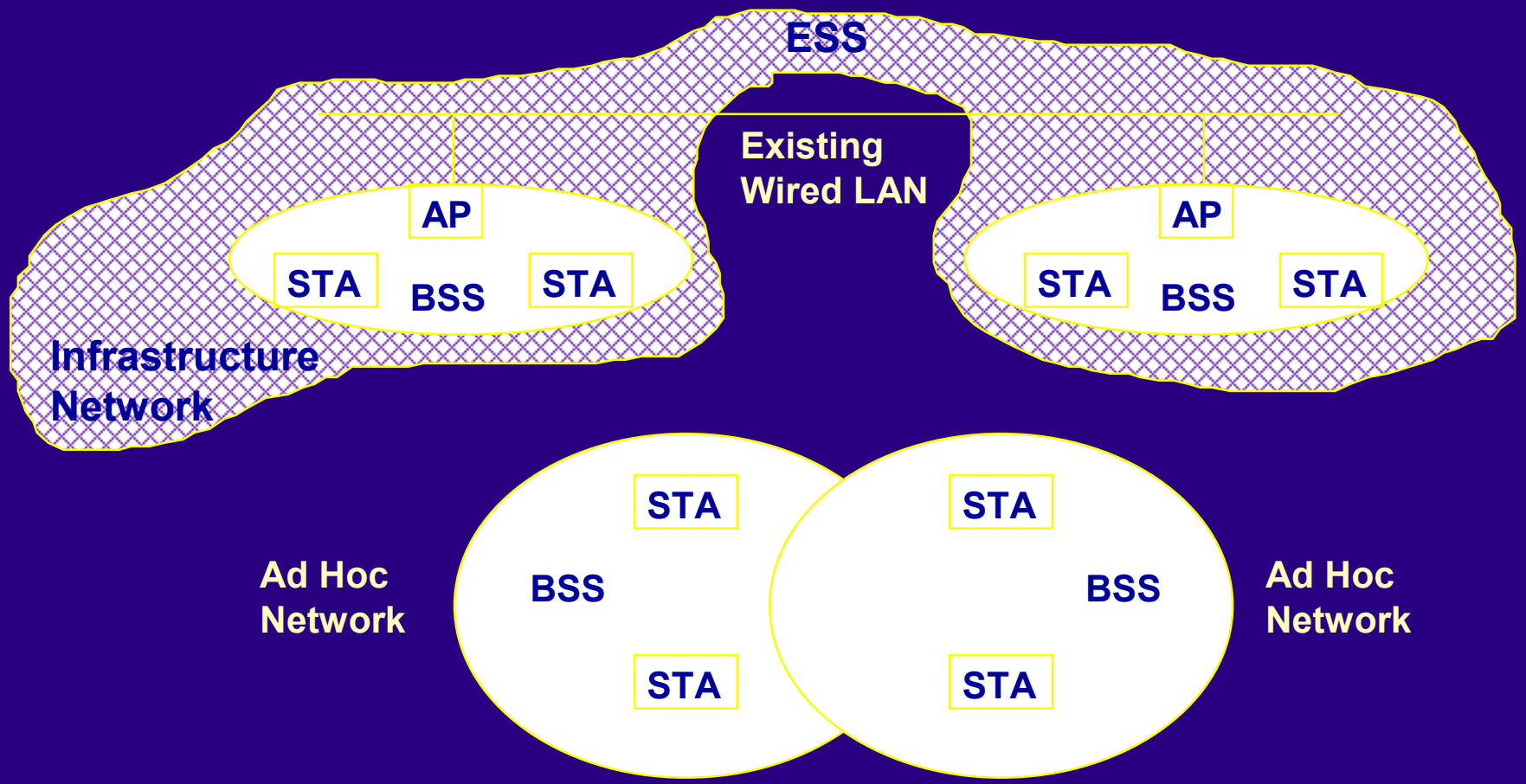
Wireless Architecture

- "Just works"
- Always connected
- Unified transport: IP
- Mobility
- Unified security model
- Adhoc
- QoS
- Performance

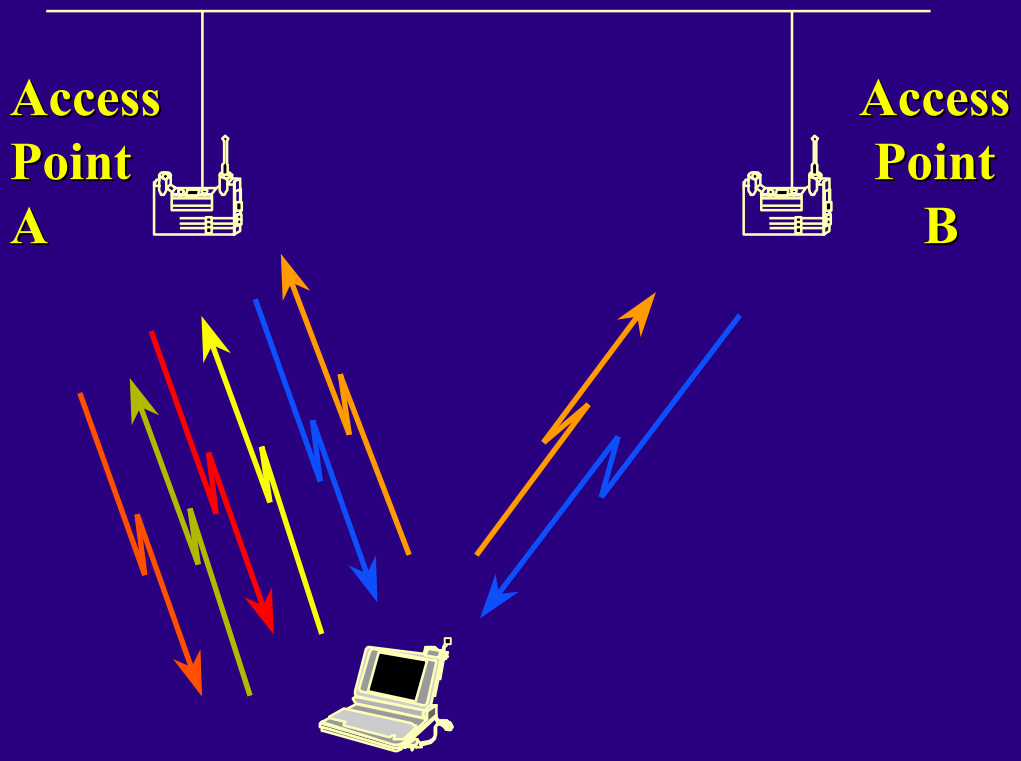
Wireless Architecture



Overview, 802.11 Architecture



WLAN's Association Process - Passive Scanning

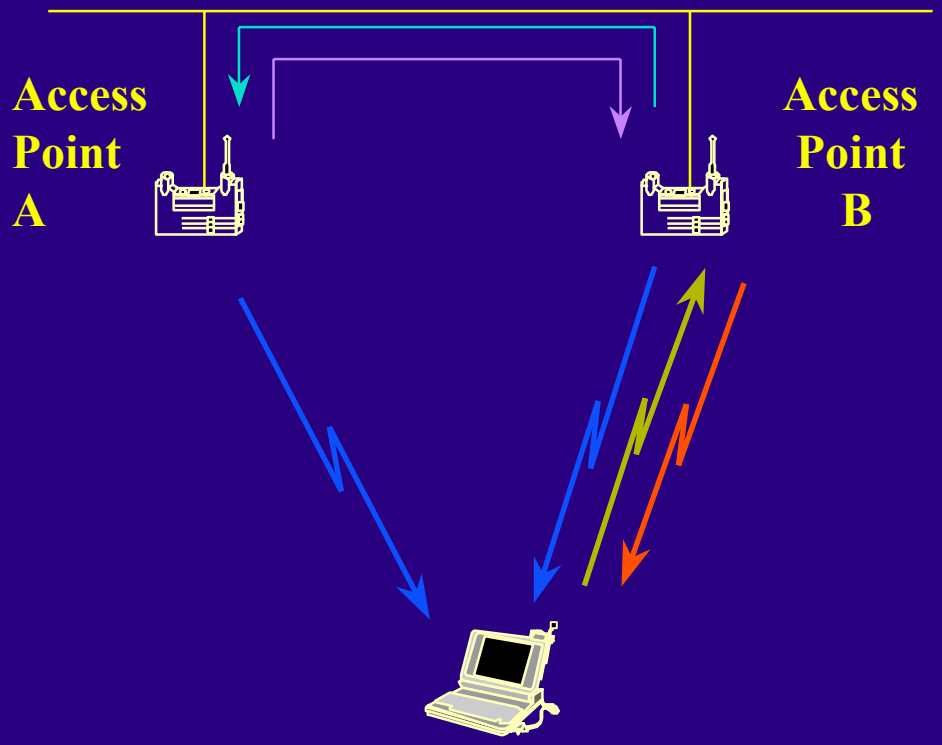


Initial connection to an Access Point

Steps to Association:

- Client sends probe
- AP sends Probe Response
- Client evaluates AP response, selects best AP.
- Client sends authentication request to selected AP (A).
- AP A confirms authentication and registers client.
- Client sends association request to selected AP (A).
- AP A confirms association and registers client.

WLAN's Re-association Process – Passive Scanning



Roaming from Access Point A to Access Point B

Steps to Re-association:

- Adapter listens for beacons from APs.
- Adapter evaluates AP beacons, selects best AP.
- Adapter sends association request to selected AP (B).
- AP B confirms association and registers adapter.
- AP B informs AP A of re-association with AP B.
- AP A forwards buffered packets to AP B and de-registers adapter.

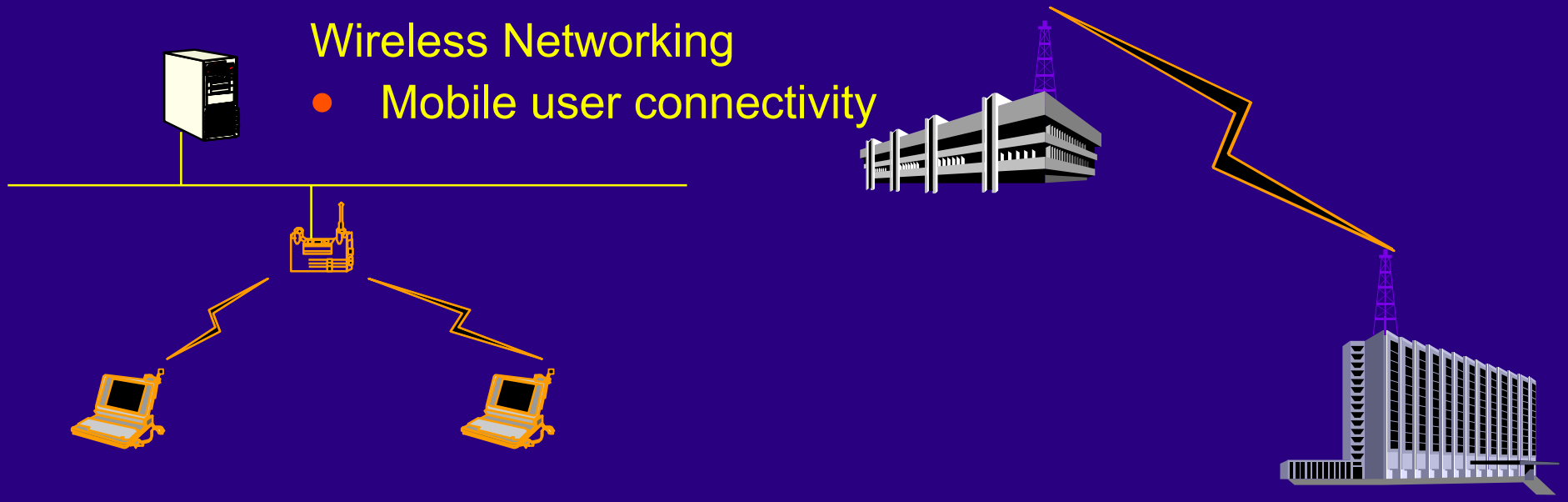
Implementations and Applications

Wireless Bridging

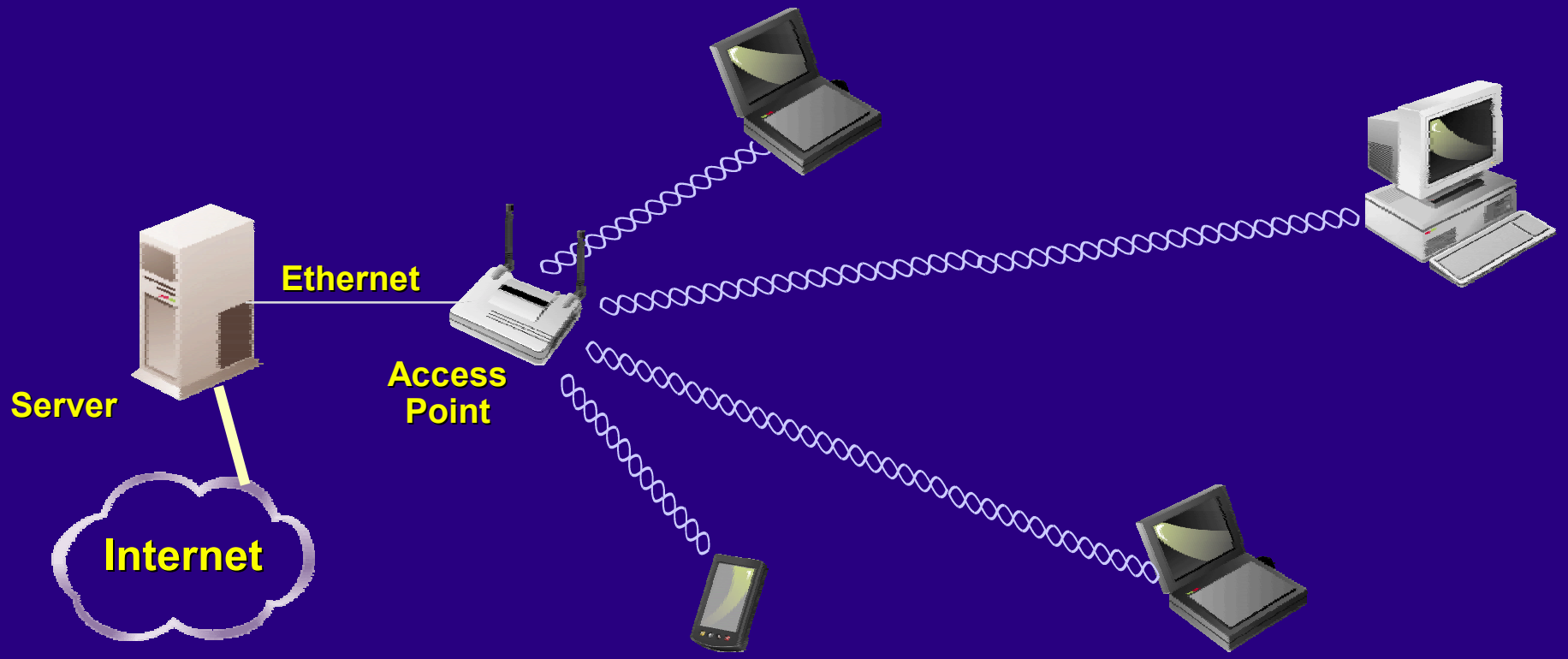
- **LAN to LAN connectivity**

Wireless Networking

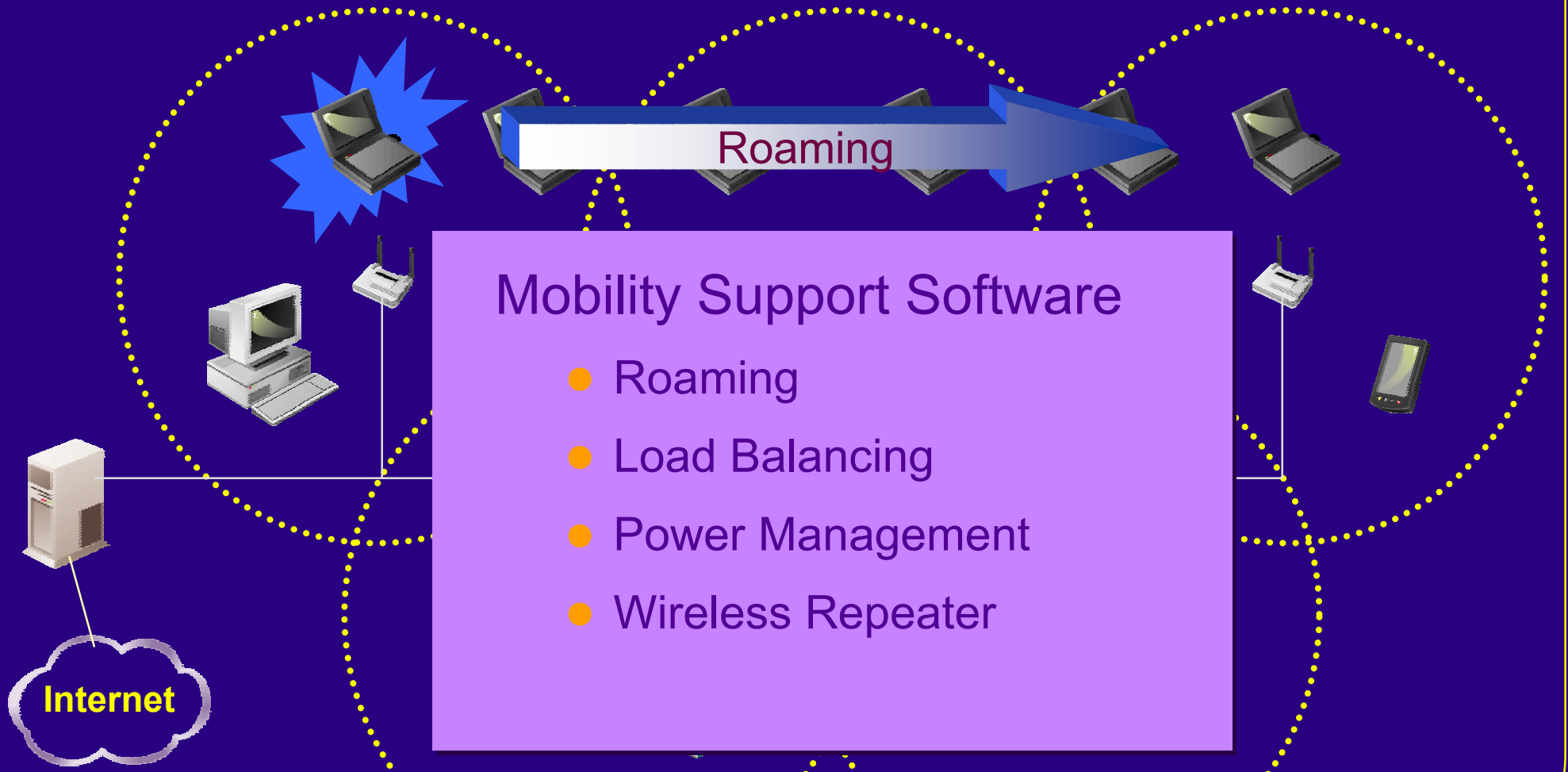
- Mobile user connectivity



Wireless Local Area Network (WLAN)



Microcellular Architecture

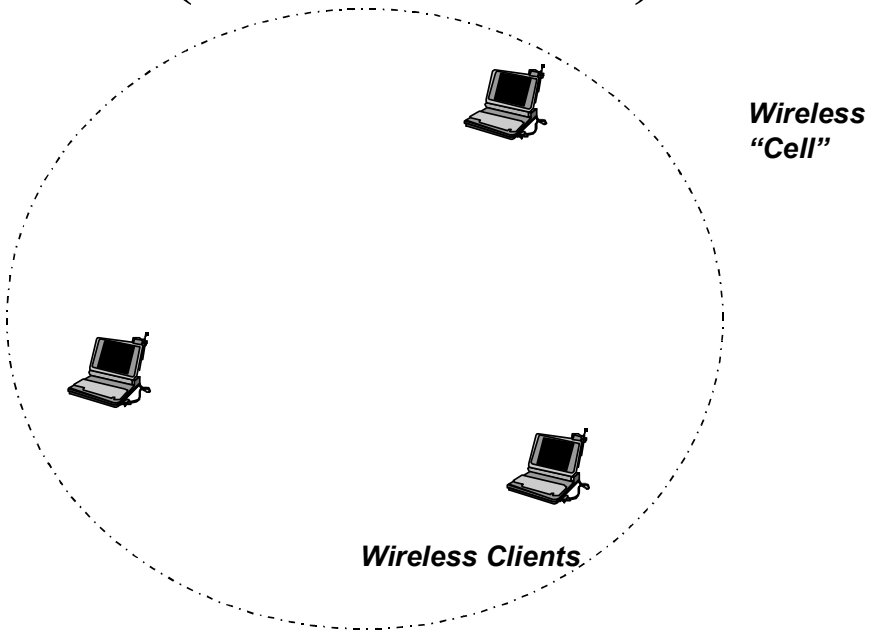


Mobility Support Software

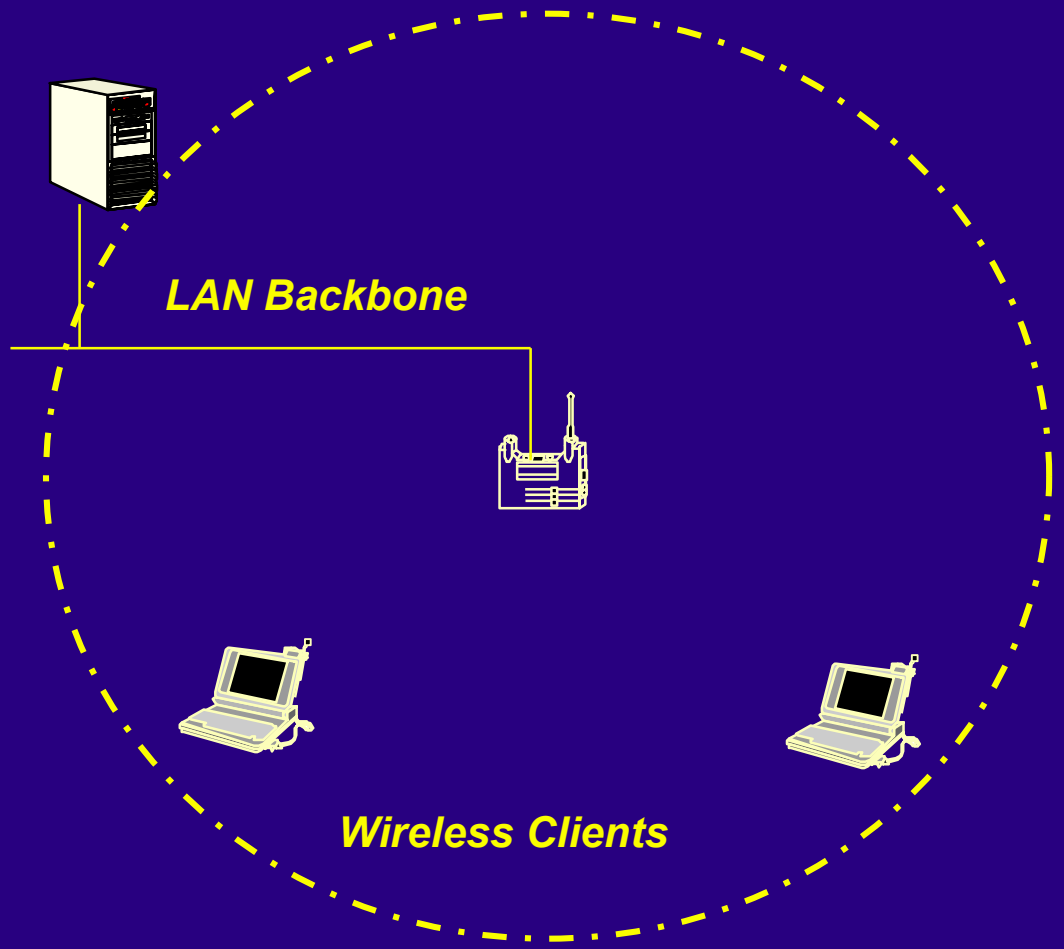
- Roaming
- Load Balancing
- Power Management
- Wireless Repeater

LAN Topologies

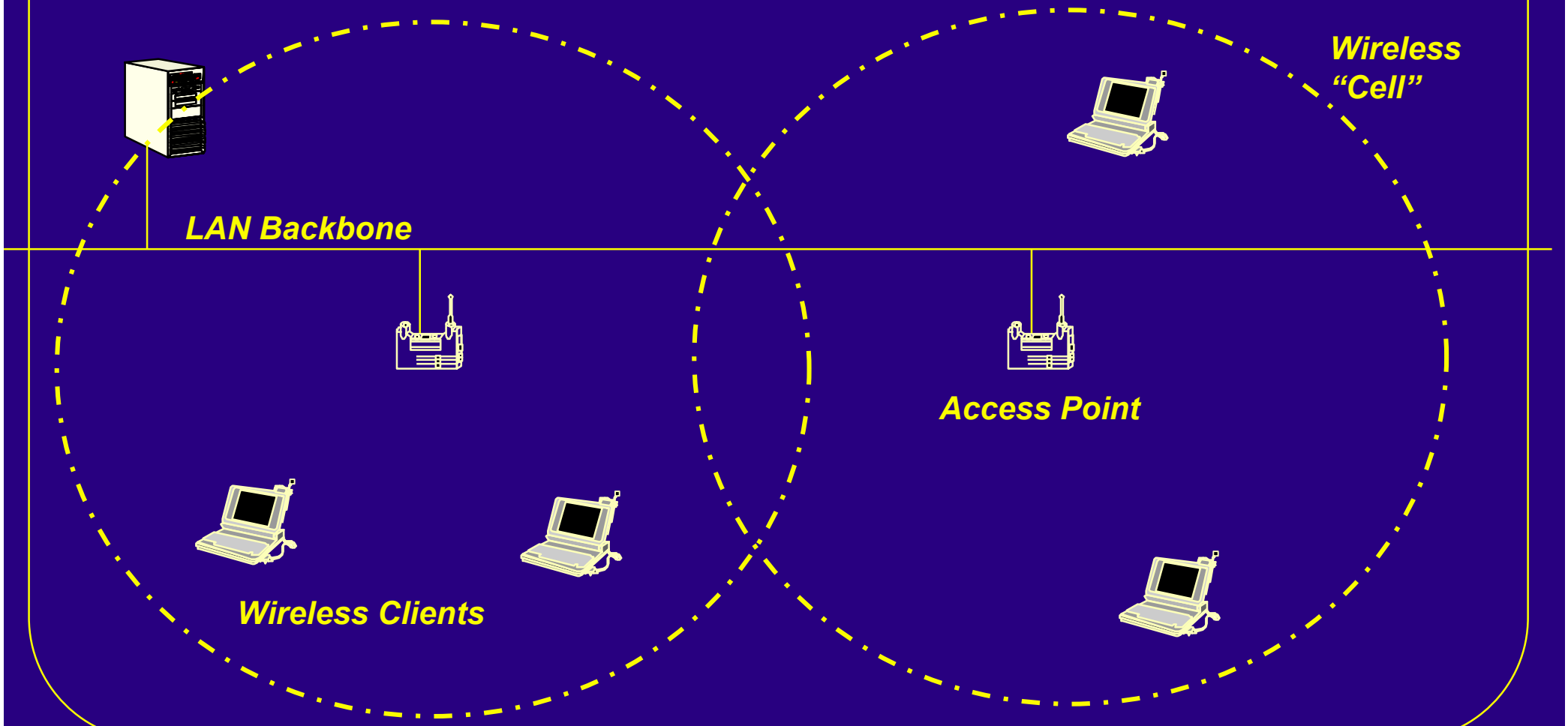
Peer to Peer Configuration (Ad Hoc mode)



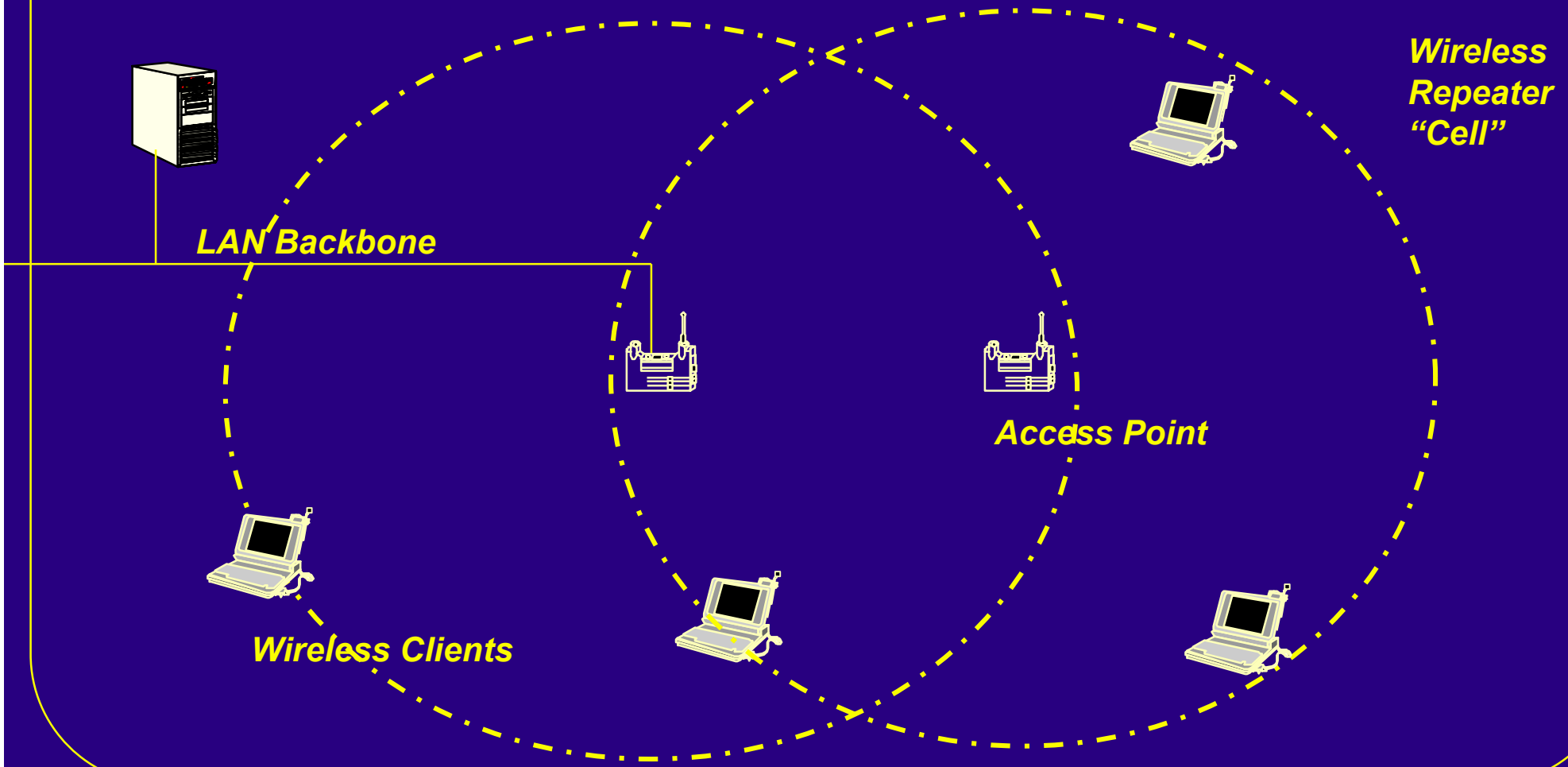
Typical Single Cell Configuration



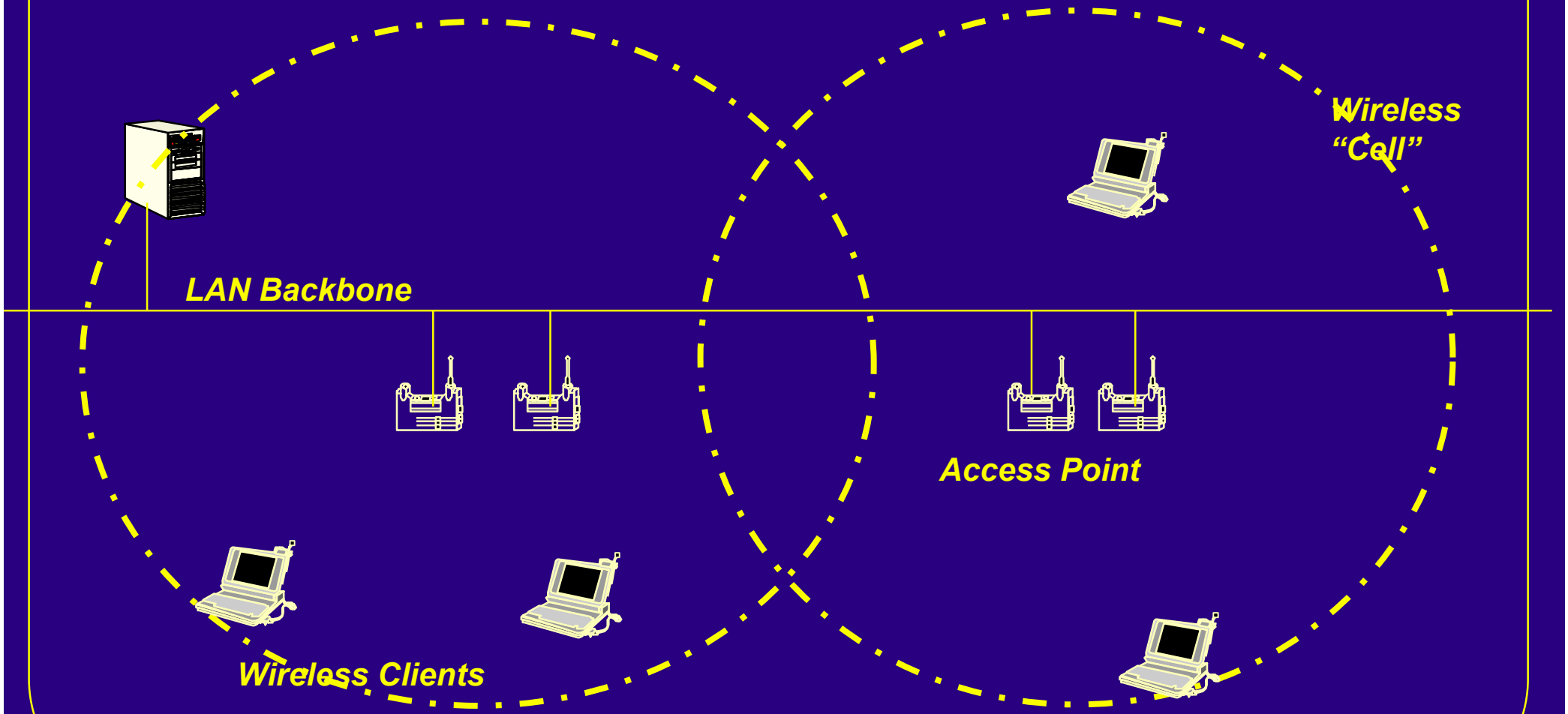
Typical Multi Cell Configuration



Wireless Repeater



System Redundancy



ARLAN/Cisco Product Families

Aironet 3500 - 2.4 GHz FH- 2Mbps (802.11)
Aironet 4500 - 2.4 GHz DS- 2Mbps (802.11)
Aironet 4800 - 2.4 GHz DS- 11Mbps (802.11)

- **Access Points**
- **LAN Adapters**

- Ethernet
- Token Ring
- PC Card
- ISA
- PCI
- Serial
- Ethernet

In-Building WLAN: Product Lines

	4800 Series	4500 Series	3500 Series
Standard	IEEE 802.11	IEEE 802.11	IEEE 802.11
Max. Data Rate	11 Mbps	2 Mbps	2 Mbps
Typical Range	125' - 350'	250' - 350'	150' - 250'
Band	2.4 GHz	2.4 GHz	2.4 GHz
Spread Radio	Direct Sequence	Direct Sequence	Frequency Hopping

4800 Series

- All the features of the 4500 plus…
- 1, 2, 5.5 and 11 Mbps
  - ⇒ 4 Mbps not supported
  - ⇒ uses CCK to achieve 11 Mbps in same 22 MHz channels
  - ⇒ 3 independent channels @ 11Mbps each!!!
- Same drivers, APs, antennas as 4500

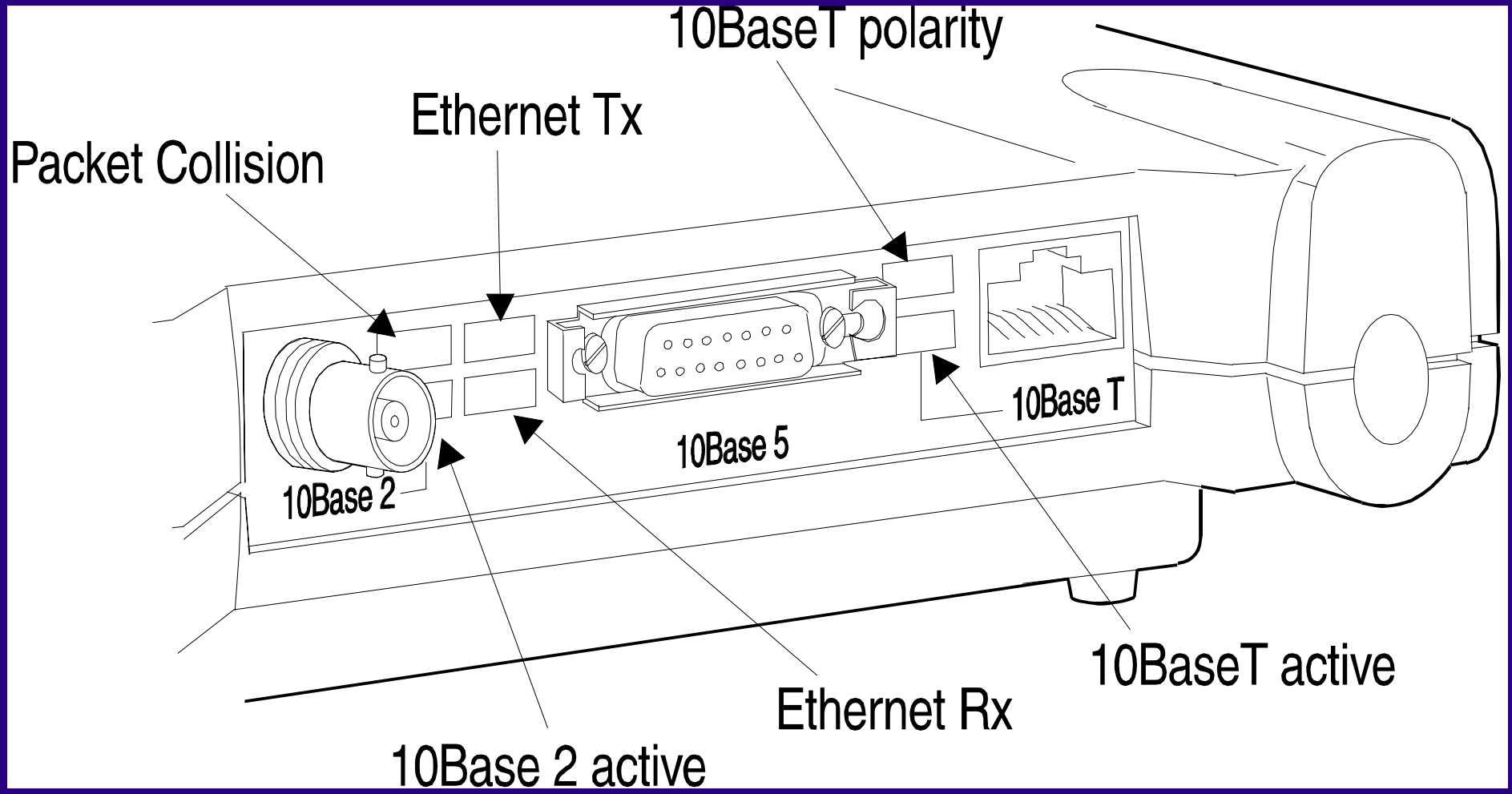
Access Points

- Menu Driver Configuration
- Minimum Setup required for normal operation
  - As little as 2 parameters to set up
- Maximum flexibility with option menus
- Internal testing for RF link
- Out -of-Band management
  - SNMP
  - Telnet
  - FTP
  - HTML (Web Browser)
  - BootP/ DHCP

Access Point Menus

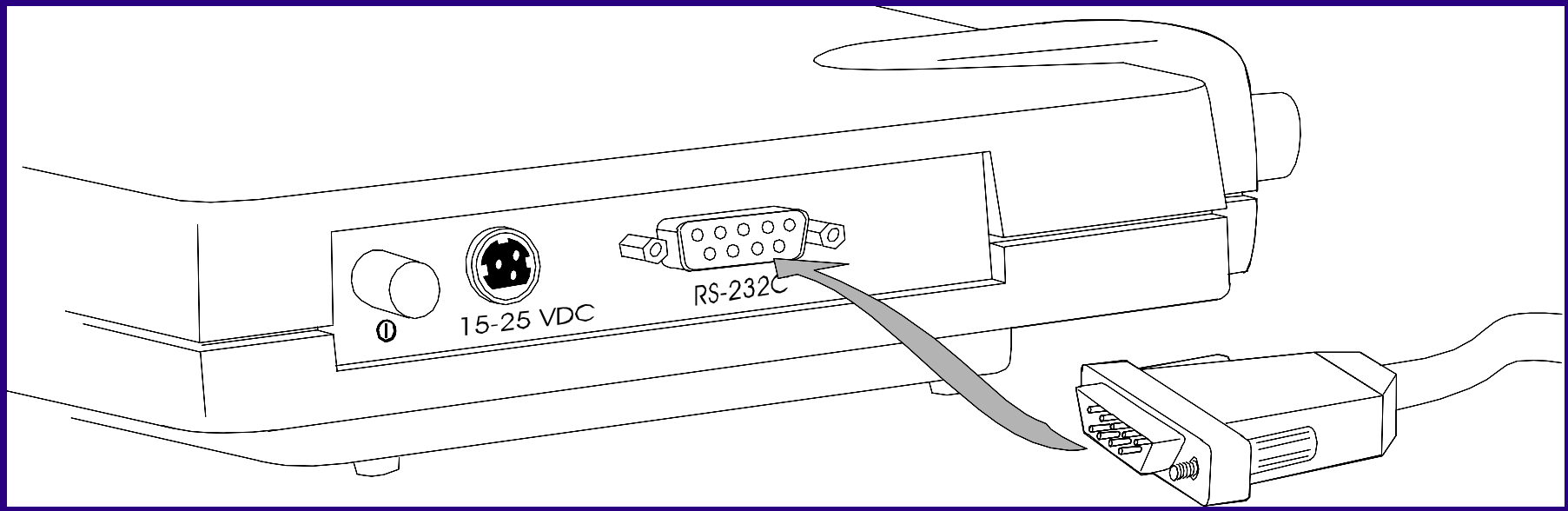
- Menus include:
  - Configuration
  - Diagnostics
  - Statistics
- Serial Communication- 9600, N,8,1
- Straight thru 9 pin cable
- Standard ANSI terminal

Top Panel LED's



Connect to Console

9600 Baud
8 Data Bits
No Parity
1 Stop Bit
Flow Control Xon/Xoff



Main Menu

```
Aironet AP4800E V7.11                Main Menu                AP4800E_263097

    Option              Value       Description

1 - Configuration    [ menu  ]    - General configuration
2 - Statistics       [ menu  ]    - Display statistics
3 - Association      [ menu  ]    - Association table maintenance
4 - Filter           [ menu  ]    - Control packet filtering
5 - Logs             [ menu  ]    - Alarm and log control
6 - Diagnostics      [ menu  ]    - Maintenance and testing commands
7 - Privilege        [ write ]    - Set privilege level
8 - Help                          - Introduction

Enter an option number or name
>
```

Configuration Menu

```
Aironet AP4800E V7.11          Configuration Menu          AP4800E_263097

    Option          Value       Description

1 - Radio         [ menu ]    - Radio network parameters
2 - Ethernet      [ menu ]    - Ethernet configuration
3 - Ident         [ menu ]    - Identification information
4 - Console       [ menu ]    - Control console access
5 - Mobile-IP     [ menu ]    - Mobile IP Protocol Configuration
6 - Time          [ menu ]    - Network Time Setup
7 - Tip           [ menu ]    - TIP Configuration
8 - Dump                      - Dump configuration to console

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Config Radio menu (AP's)

```
Aironet AP4800E V7.11          Configuration Radio Menu
AP4800E_263097

    Option              Value          Description

1 - Ssid            [ "tsunami" ]    - Service set identification
2 - Root            [    on     ]    - Enable root mode
3 - Rates           [   1_11    ]    - Allowed bit rates in
megabits/second
4 - Basic_rates     [     1     ]    - Basic bit rates in megabits/second
5 - Frequency       [   2437    ]    - Center frequency in MHz
6 - I80211          [   menu    ]    - 802.11 parameters
7 - Linktests       [   menu    ]    - Test the radio link
8 - Extended        [   menu    ]    - Extended parameters

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Config Radio menu (BR's)

```
Aironet BR500E V7.11          Configuration Radio Menu          BR500E_263097

    Option              Value        Description

1 - Ssid             [ "fred" ]    - Service set identification
2 - Root             [   on   ]    - Enable root mode
3 - Rates            [  1_11  ]    - Allowed bit rates in megabits/second
4 - Basic_rates      [   1    ]    - Basic bit rates in megabits/second
5 - Frequency        [  2437  ]    - Center frequency in MHz
6 - Distance         [   0    ]    - Maximum separation in kilometers
7 - I80211           [  menu  ]    - 802.11 parameters
8 - Linktests        [  menu  ]    - Test the radio link
9 - Extended         [  menu  ]    - Extended parameters

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

802.11 Menu

```
Aironet AP4800E V7.11    Configuration Radio I80211 Menu
AP4800E_263097

    Option              Value      Description

1 - Beacon            [ 100  ]    - Beacon period in Kusec
2 - Dtim              [  2   ]    - DTIM interval
3 - Extend            [  on  ]    - Allow proprietary extensions
4 - Bcst_ssid         [  on  ]    - Allow broadcast SSID
5 - Rts               [ 2048 ]    - RTS/CTS packet size threshold
6 - Privacy           [ menu ]    - Privacy configuration
7 - Encapsulation     [ menu ]    - Configure packet encapsulation

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Encryption Menu

```
Aironet AP4800E V7.11 Configuration Radio I80211 Privacy Menu   AP4800E_263097

    Option          Value      Description

1 - Encryption    [ off  ]    - Encrypt radio packets
2 - Client        [ open ]    - Client authentication modes allowed
3 - Key                       - Set the default key

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

802.11 Encapsulation Menu

```
Aironet AP4800E V7.11 Configuration Radio I80211 Encapsulation Menu AP4800E_263097

    Option      Value       Description

1 - Encap     [ 802.1H ]    - Default encapsulation method
2 - Show                    - Show encapsulation table
3 - Add                     - Add a protocol encapsulation method
4 - Remove                  - Remove a protocol encapsulation method

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Encapsulation Menu (cont.)

```
Aironet AP4800E V7.11 Configuration Radio I80211 Encapsulation Menu AP4800E_263097

    Option      Value       Description

1 - Encap     [ 802.1H ]    - Default encapsulation method
2 - Show                    - Show encapsulation table
3 - Add                     - Add a protocol encapsulation method
4 - Remove                  - Remove a protocol encapsulation method

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Radio Extended Menu (AP's)

```
Aironet AP4800E V7.11   Configuration Radio Extended Menu       AP4800E_263097

    Option          Value      Description

1 - Time_retry    [  8   ]   - Number of seconds to retry transmit
2 - Count_retry   [  0   ]   - Maximum number transmit retries
3 - Balance       [ off  ]   - Load balancing
4 - Diversity     [  on  ]   - Enable the diversity antennas
5 - Modulation    [ cck  ]
6 - Power                    - Transmit power level
7 - Fragment      [ 2048 ]   - Maximum fragment size

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Radio Extended Menu (BR's)

```
Aironet BR500E V7.11    Configuration Radio Extended Menu        BR500E_263097

    Option                Value           Description

1 - Bridge_mode    [ access_point ]    - Bridging mode
2 - Time_retry     [       8      ]    - Number of seconds to retry transmit
3 - Count_retry    [       0      ]    - Maximum number transmit retries
4 - Balance        [      off     ]    - Load balancing
5 - Diversity      [      off     ]    - Enable the diversity antennas
6 - Modulation     [      cck     ]
7 - Power                              - Transmit power level
8 - Fragment       [     2048     ]    - Maximum fragment size

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Ethernet Menu

```
Aironet AP4800E V7.11      Configuration Ethernet Menu          AP4800E_263097

    Option       Value      Description

1 - Active     [ off  ]   - Connection active
2 - Size       [ 1518 ]   - Maximum frame size
3 - Port       [ auto ]   - Port selection
4 - Fallback   [ off  ]   - Become repeater on LAN cable fault

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Identification Menu

```
Aironet AP4800E V7.11        Configuration Ident Menu          AP4800E_263097

     Option                Value              Description

1   - Inaddr        [ 000.000.000.000  ]    - Internet address
2   - Inmask        [ 000.000.000.000  ]    - Internet subnet mask
3   - Gateway       [ 000.000.000.000  ]    - Internet default gateway
4   - Routing       [       menu       ]    - IP routing table configuration
5   - Dns1          [ 000.000.000.000  ]    - DNS server 1
6   - Dns2          [ 000.000.000.000  ]    - DNS server 2
7   - Domain        [         ""       ]    - Domain name
8   - Nid           [   004096263097   ]    - Network address
9   - Name          [ "AP4800E_263097" ]    - Node name
01  - Location      [         ""       ]    - System location
02  - Contact       [         ""       ]    - System contact name
03  - Bootp_DHCP    [        on        ]    - Use BOOTP/DHCP on startup
04  - Class         [    "AP4800E"     ]    - DHCP class id

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Identification Routing Menu

```
Aironet AP4800E V7.11    Configuration Ident Routing Menu       AP4800E_263097

    Option    Value    Description

1 - Display           - Display Route Table Entries
2 - Host              - Add a Static Host Route
3 - Net               - Add a Static Network Route
4 - Delete            - Delete a Static Route

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Console Menu

```
Aironet AP4800E V7.11       Configuration Console Menu          AP4800E_263097

     Option              Value         Description

1  - Rpassword                        - Set readonly privilege password
2  - Wpassword                        - Set write privilege password
3  - Remote          [    on    ]     - Allow remote operators
4  - Display                          - Display the remote operator list
5  - Add                              - Add an operator host
6  - Delete                           - Remove an operator host
7  - Communities     [   menu   ]     - SNMP community properties
8  - Type            [ teletype ]     - Terminal type
9  - Port            [   menu   ]     - Serial port set-up
01 - Linemode        [   off    ]     - Console expects complete lines

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Mobile-IP Menu

```
Aironet AP4800E V7.11      Configuration Mobile-IP Menu          AP4800E_263097

    Option          Value      Description

1 - AgentType    [ off  ]    - Home / Foreign Agent
2 - Mobile                   - Home Agent Active Mobile Nodes
3 - Visitors                 - Foreign Agent Visitor List
4 - Add                      - Add Mobile Nodes
5 - Remove                   - Remove Mobile Nodes
6 - Display                  - Display Home Agent Authorized Addresses
7 - Setup        [ menu ]    - Agent Configuration
8 - Advert       [ menu ]    - Advertisement Setup

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Mobile-IP Setup Menu

```
Aironet AP4800E V7.11   Configuration Mobile-IP Setup Menu      AP4800E_263097

    Option                Value          Description

1 - Lifetime          [    600     ]    - Max Registration Lifetime
2 - ReplayProt        [ timestamps ]    - Replay Protection Method
3 - Broadcasts        [    off     ]    - Broadcast Forwarding
4 - RegRequired       [     on     ]    - Registration Required
5 - HostRedirects     [    off     ]    - Enable ICMP Host Redirects to MN

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Mobile-IP Advert Menu

```
Aironet AP4800E V7.11  Configuration Mobile-IP Advert Menu      AP4800E_263097

    Option                Value          Description

1 - AdvertType        [ multicast ]    - Advertisment type
2 - AdvertInterval    [     5     ]    - Advertisement interval
3 - PrefixLen         [    off    ]    - Advertise prefix length extension
4 - AdvertRtrs        [    on     ]    - Advertise routers

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Time Menu

```
Aironet AP4800E V7.11        Configuration Time Menu          AP4800E_263097

    Option                  Value              Description

1 - Time_server    [ 000.000.000.000 ]    - Time protocol server
2 - Sntp_server    [ 000.000.000.000 ]    - Network time server
3 - Offset         [         0       ]    - GMT offset in minutes
4 - Dst            [       off       ]    - Use daylight savings time

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Statistics

```
Aironet AP4800E V7.11              Statistics Menu                  AP4800E_263097

     Option            Value      Description

1   - Throughput                  - Throughput statistics
2   - Radio                       - Radio error statistics
3   - Status                      - Display general status
4   - Map                         - Show network map
5   - Watch                       - Record history of a statistic
6   - History                     - Display statistic history
7   - Nodes                       - Node statistics
8   - ARP                         - ARP table
9   - Display_time    [ 10  ]    - Time to re-display screens
01  - IpAdr           [ off ]    - Determine client IP addresses

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Throughput Statistics

```
Aironet AP4800E V7.11          THROUGHPUT STATISTICS              AP4800E_263097
Cleared 3:56:55 ago

                                      Recent                      Ave     Highest
Statistic                             Rate/S      Total           Rate/S     Rate/S
------------------------------ ---------- ---------- ---------- ----------
Radio Receive       Packets            0       2004          0         20
                    Bytes              0     100928          7      11029
                    Filtered           0          0          0          0
                    Errors             0         21          0          0

Radio Transmit      Packets            0        621          0         20
                    Multicasts         0        517          0          0
                    Bytes              0     112690          7      11040
                    Errors             0         21          0          4

Ethernet Receive    Packets            0          0          0          0
                    Bytes              0          0          0          0
                    Filtered           0          0          0          0
                    Errors             0          0          0          0
                    Misses             0          0          0          0

Ethernet Transmit   Packets            0          0          0          0
                    Bytes              0          0          0          0
                    Errors             0          0          0          0

Enter space to redisplay, C[lear stats], q[uit] :
```

Radio Statistics

```
Aironet AP4800E V7.11          RADIO ERROR STATISTICS          AP4800E_263097
Cleared 0:02:15 ago

Receive                                      Transmit
-------------------------------------------  -------------------------------------
Buffer full frames lost              0       Retries                          0
Duplicate frames                     0       Max retries / frame              0
CRC errors                           0       Excessive retries                0
Decrypt errors                       0       Queue full discards              0
                                             Holdoffs                    32 +32
                                             Holdoff timeouts                 0

Enter space to redisplay, C[lear stats], q[uit] :
```

Status

```
Aironet AP4800E V7.11                  Status                      AP4800E_263097
Uptime : 0:02:22                                                IP: 000.000.000.000

---------------------------------- Radio ----------------------------------
-
SID        : tsunami            Bitrate   : 1_11 Mb/s           Radio   : 4800
Root       : on                 Frequency : 2437 MHz            Carrier : US_Can
                                                                Power   : full
Autoreg    : on                 Nodes     : 0 connected

---------------------------------- Ethernet -------------------------------
-
Active     : off                              Rcv/Xmt : 0/0  Pkt/sec

---------------------------------- Filters --------------------------------
-
Multicast : forward (0 set)                     Protocols : off     (0 set)
Source    : off     (0 set)


Enter space to redisplay, q[uit] :
```

Radio Node Statistics

```
Aironet AP4800E V7.11          RADIO NODE STATISTICS                AP4800E_263097

 Id    Address     Signal    Tx Pkt    Tx Byte   Retry    Rx Pkt    Rx Byte Rate
--- ------------ ------- --------- ---------- ------- --------- ---------- ----
  1 004096125e10   1/0           1        102       0         0          0    2

Enter space to redisplay, C[lear stats], q[uit] :
```

Association Menu

```
Aironet AP4800E V7.11            Association Menu                AP4800E_263097

    Option       Value         Description

1 - Display                    - Display the table
2 - Summary                    - Display the table summary
3 - Maximum    [  1024   ]     - Maximum allowed child nodes
4 - Autoreg    [   on    ]     - Allow automatic table additions
5 - Add                        - Control node access
6 - Remove                     - Remove access control
7 - Niddisp    [ numeric ]     - Node Ids display mode

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Association Table

```
Enter one of [all, connected, radio-only, hierarchy, controlled] : all

Aironet BR500E V7.11        Association Table Entries            BR500E_263097

   Address       Device  Type    Parent     Name                 Src Edst Rdst
------------- --------- ---- ------------ ------------------ --- ---- ----
 0000c00ece4b   Eclient      004096125e10                      Fwd  Fwd  Fwd
 004096125e10   UC4500E             Local UC_client                 Fwd
 00409624eb81    BR500E  Rep         Local BR500E_24eb81             Fwd
 004096263097    BR500E   Me               BR500E_263097      Fwd  Fwd  Fwd
 00c04ff4da63     Enode              Local
 02608c6d03c8     Unkwn      00409624eb81

Enter space to redisplay, q[uit] :
```

Filter Menu's

```
Aironet AP4800E V7.11                Filter Menu                    AP4800E_263097

    Option          Value          Description

1 - Multicast   [   menu    ]   - Multicast address filtering
2 - Node        [   menu    ]   - Node address filtering
3 - Protocols   [   menu    ]   - Protocol filters
4 - Proxy_arp   [   off     ]   - Activate proxy ARP function
5 - Direction   [ to_radio  ]   - Packet direction affected by filters

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Multicast Filters

```
Aironet AP4800E V7.11          Filter Multicast Menu              AP4800E_263097

    Option              Value          Description

1 - Default       [  forward   ]    - Default multicast action
2 - Show                            - Display the multicast filters
3 - Add                             - Add a multicast address filter
4 - Remove                          - Remove a multicast address filter
5 - Radio_mcst    [ everywhere ]    - Where to forward multicasts from radio

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Node Filtering

```
Aironet AP4800E V7.11              Filter Node Menu                AP4800E_263097

    Option       Value      Description

1 - Source      [ off ]    - Source addresses
2 - Display                - Display the node address filters
3 - Ipdisplay              - Display the IP address filters
4 - Add                    - Add a node address filter
5 - Remove                 - Remove a node address filter

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Protocol Filtering

```
Aironet AP4800E V7.11          Filter Protocols Menu              AP4800E_263097

    Option      Value       Description

1 - Default    [ off ]    - Default action
2 - Unicast    [ off ]    - Filter unicast packets
3 - Display               - Display the protocol filters
4 - Add                   - Add a protocol filter
5 - Remove                - Remove a protocol filter
6 - Length     [ 22  ]    - Length of packet data to log
7 - Monitor    [ off ]    - Protocol monitoring enabled
8 - Show                  - Show forwarded protocol list
9 - Clear                 - Clear forwarded protocol list

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Protocol Monitor

Aironet Bridge Vx.xx PROTOCOLS FOUND BR2000 _11090b

--------LLC----------

	Name	Source	Count	Protocol	SAPs	OUI	Protocol
1.	IPX	Lan	1063		ffff		
2.	NetBIOS	Lan	11		f0f0		
3.	IP	Lan	36	0800			
4.	ARP	Lan	1	0806			

Enter space to redisplay, C[lear stats], q[uit] :

Logs Menu

```
Aironet AP4800E V7.11                  Logs Menu                    AP4800E_263097

    Option                Value                Description

1 - History                                  - Log and alarm history
2 - Clear                                    - Clear the history buffer
3 - Printlevel    [        all         ]     - Type of logs to print
4 - Loglevel      [        all         ]     - Type of logs to save
5 - Ledlevel      [  error/severe      ]     - Type of logs to light status led
6 - Statistics                               - Set alarms on statistics
7 - Network       [        off         ]     - Log network roaming
8 - Syslog        [ 000.000.000.000    ]     - Unix syslogd address
9 - Snmp          [       menu         ]     - Set-up SNMP traps

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Snmp Menu

```
Aironet AP4800E V7.11              Logs Snmp Menu                AP4800E_263097

    Option          Value          Description

1 - Trapdest    [   none    ]    - IP destination for SNMP traps
2 - Trapcomm    [ "public" ]     - Community for SNMP traps
3 - Loglevel    [   off     ]    - Type of logs to cause a trap
4 - Authtrap    [   off     ]    - Enable authentication failure trap

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Diagnostics

```
Aironet AP4800E V7.11            Diagnostics Menu              AP4800E_263097

    Option          Value       Description

1 - Network       [ menu ]    - Network connection commands
2 - Linktests     [ menu ]    - Test the radio link
3 - Restart                   - Restart the unit
4 - Shutdown                  - Prepare to power off unit
5 - Defaults                  - Return to default configuration
6 - Reset                     - Default parts of the configuration
7 - Load          [ menu ]    - Load new version of firmware

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Diagnostics Network Menu

```
Aironet AP4800E V7.11          Diagnostics Network Menu          AP4800E_263097

    Option          Value          Description

1 - Connect                      - Start telnet session
2 - Escape      [ "^X^Y^Z" ]     - Connection escape sequence
3 - Ping                         - Send an IP PING packet
4 - Find        [   off    ]     - Flash LEDs to find unit

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Linktests Menu

```
Aironet AP4800E V7.11       Diagnostics Linktests Menu          AP4800E_263097

     Option          Value      Description

1   - Strength                   - Run a signal strength test
2   - Carrier                    - Carrier busy statistics
3   - Multicast                  - Run a multicast echo test
4   - Unicast                    - Run a unicast echo test
5   - Remote                     - Run a remote echo test
6   - Destination   [ any  ]     - Target address
7   - Size          [ 512  ]     - Packet size
8   - Count         [ 100  ]     - Number of packets to send
9   - Errors                     - Radio error statistics
01  - Autotest      [ once ]     - Auto echo test
02  - Continuous    [  0   ]     - Repeat echo test once started

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Carrier Busy Statistics

```
Enter space to redisplay, q[uit] :

Aironet AP4800E V7.11        CARRIER BUSY / FREQUENCY          AP4800E_263097

       *
       *
       *
       *   * *
       *   * *
     * * * * * *
     * * * * * *
*    * * * * * * *
*    * * * * * * *
* * * * * * * * *
1 1 2 2 3 3 4 4 5 5 6
2 7 2 7 2 7 2 7 2 7 2

Highest point = 18% utilization

Enter space to redisplay, q[uit] :
```

Load Menu

```
Aironet AP4800E V7.11          Diagnostics Load Menu              AP4800E_263097

    Option            Value          Description

1 - Xmodem                          - Xmodem load from serial port
2 - Crc-xmodem                      - Xmodem-CRC load from serial port
3 - Ftp           [   menu    ]     - Load using FTP
4 - Distribute    [   menu    ]     - Distribute the firmware
5 - Bootp_DHCP    [    on     ]     - Use BOOTP/DHCP on startup
6 - Class         [ "AP4800E" ]     - DHCP class id

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Load Ftp Menu

```
Aironet AP4800E V7.11       Diagnostics Load Ftp Menu          AP4800E_263097

    Option              Value              Description

1 - Get                                  - Load a firmware/config file
2 - Put                                  - Send a firmware file
3 - Config                               - Send a configuration file
4 - Dest         [ 000.000.000.000 ]     - Host IP address
5 - Username     [       ""        ]     - Host username
6 - Password                             - Host password
7 - Filename     [       ""        ]     - Host filename

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

Load Distribute Menu

```
Aironet AP4800E V7.11    Diagnostics Load Distribute Menu       AP4800E_263097

    Option        Value        Description

1 - Go                       - Start a distribution
2 - Type      [ firmware ]   - What to distribute
3 - Control   [  newer   ]   - How to control distributions

Enter an option number or name, "=" main menu, <ESC> previous menu
>
```

STP Menu for BR's

Aironet Bridge Vx.x Configuration Stp Menu BR500 _11090b

Option	Value	Description
1 - Active	[on]	- Protocol enabled
2 - Bridge	[menu]	- Bridge parameters
3 - Port	[menu]	- Port parameters
4 - Display		- Protocol status
5 - State	["Forward"]	- Local ethernet port state

Enter an option number or name, "=" main menu, <ESC> previous menu
>

WIN DGS Utilities

- Windows based Graphical User Interface software utility
  - ⇒ Flash upgrade to the client
  - ⇒ Reconfigure the PC Card
  - ⇒ Link Test
  - ⇒ Site Survey capability using the Link Test
- Users can more easily upgrade firmware, assess link integrity and performance, and optimize client connections

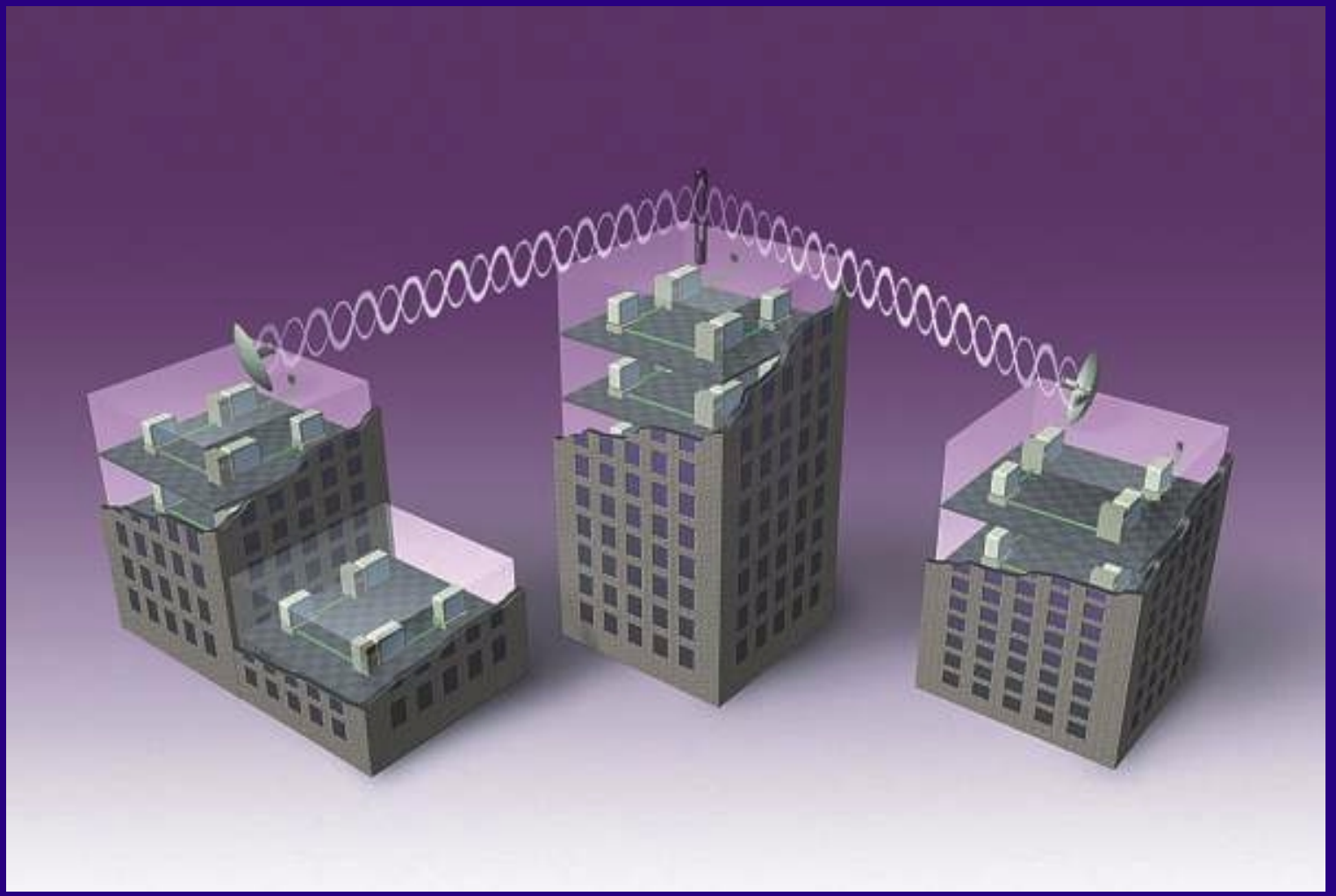
Network Drivers

- Client Cards supplied with:
  - Novel type-
    - ⇒ ODI drivers
  - Microsoft products Drivers-
    - ⇒ NDIS 2.0- DOS, Windows 3.1, Windows for Workgroups
    - ⇒ NDIS 3.1- Win 95, Win NT
  - FTP- TCP/IP
    - ⇒ Packet driver

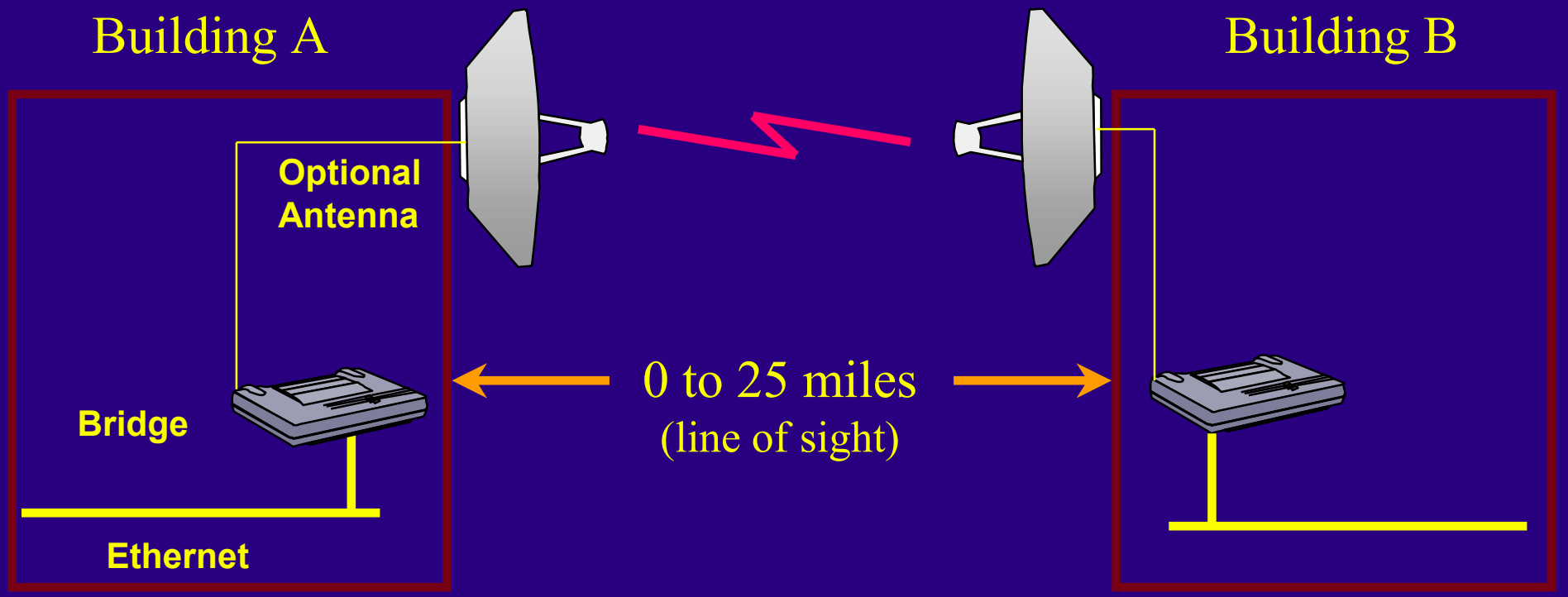
Aironet Model Numbers

- Product model numbers consist of a 2 or 3-letter code for product type, followed by the family number, followed by an optional code for interface type.
- The product types are:
  - AP Access Point
  - BR Bridge
  - ISA ISA Card
  - PCI PCI Card
  - PC PCMCIA Card
  - UC Universal Client (Serial, Ethernet)
  - MC Multi Port Client

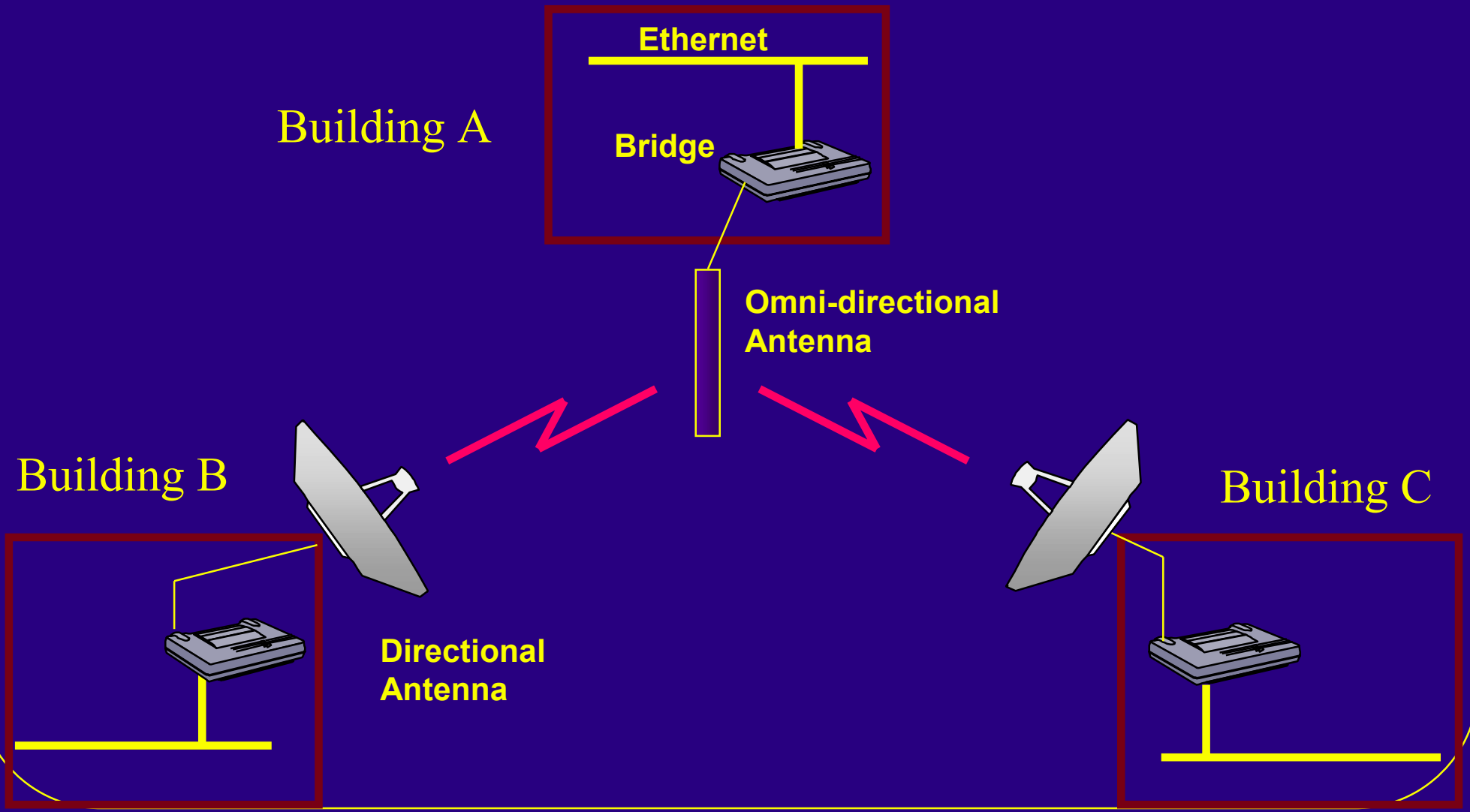
Wireless Bridging



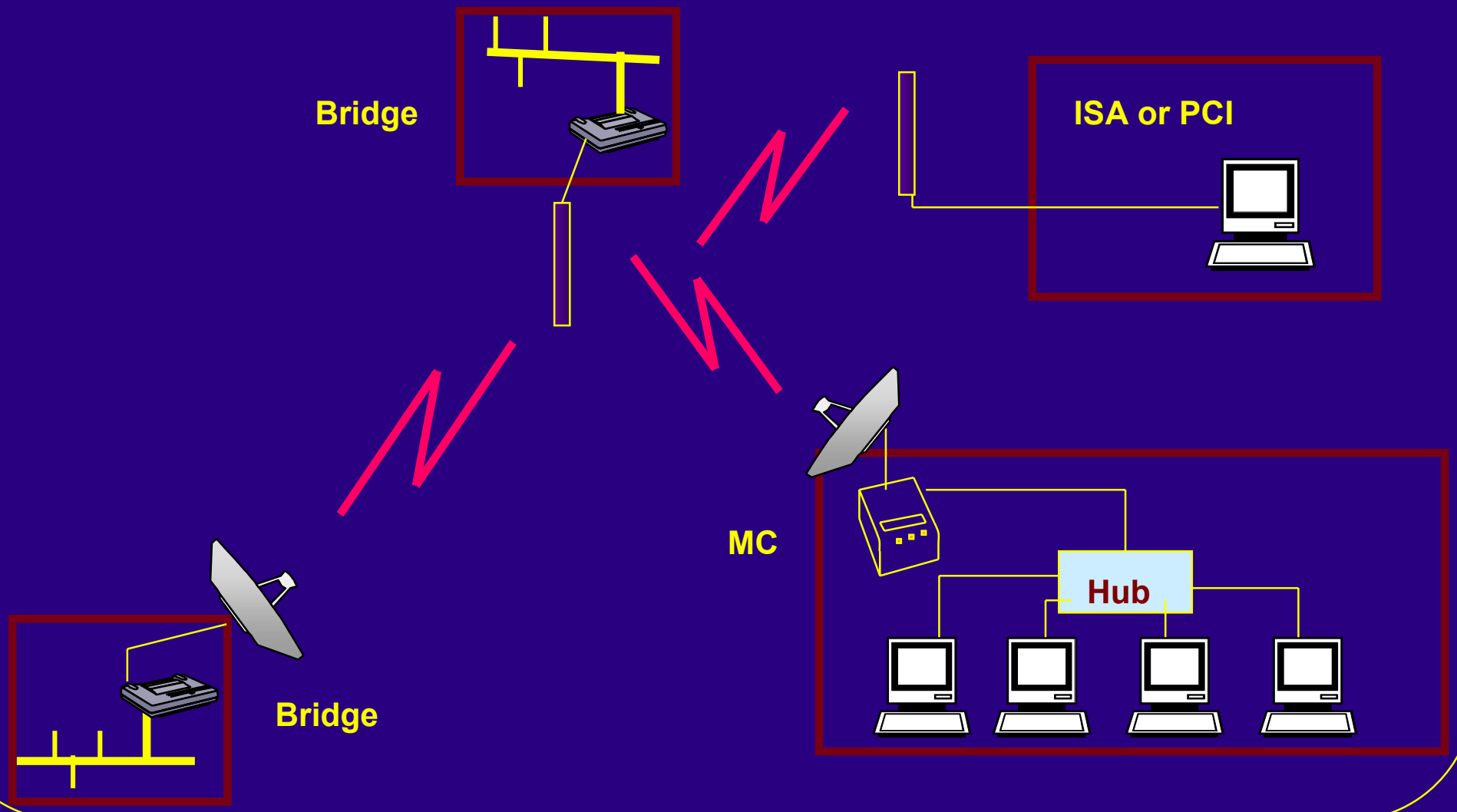
Point-to-Point Configuration



Point-to-Multipoint Configuration



New Addition to the system!

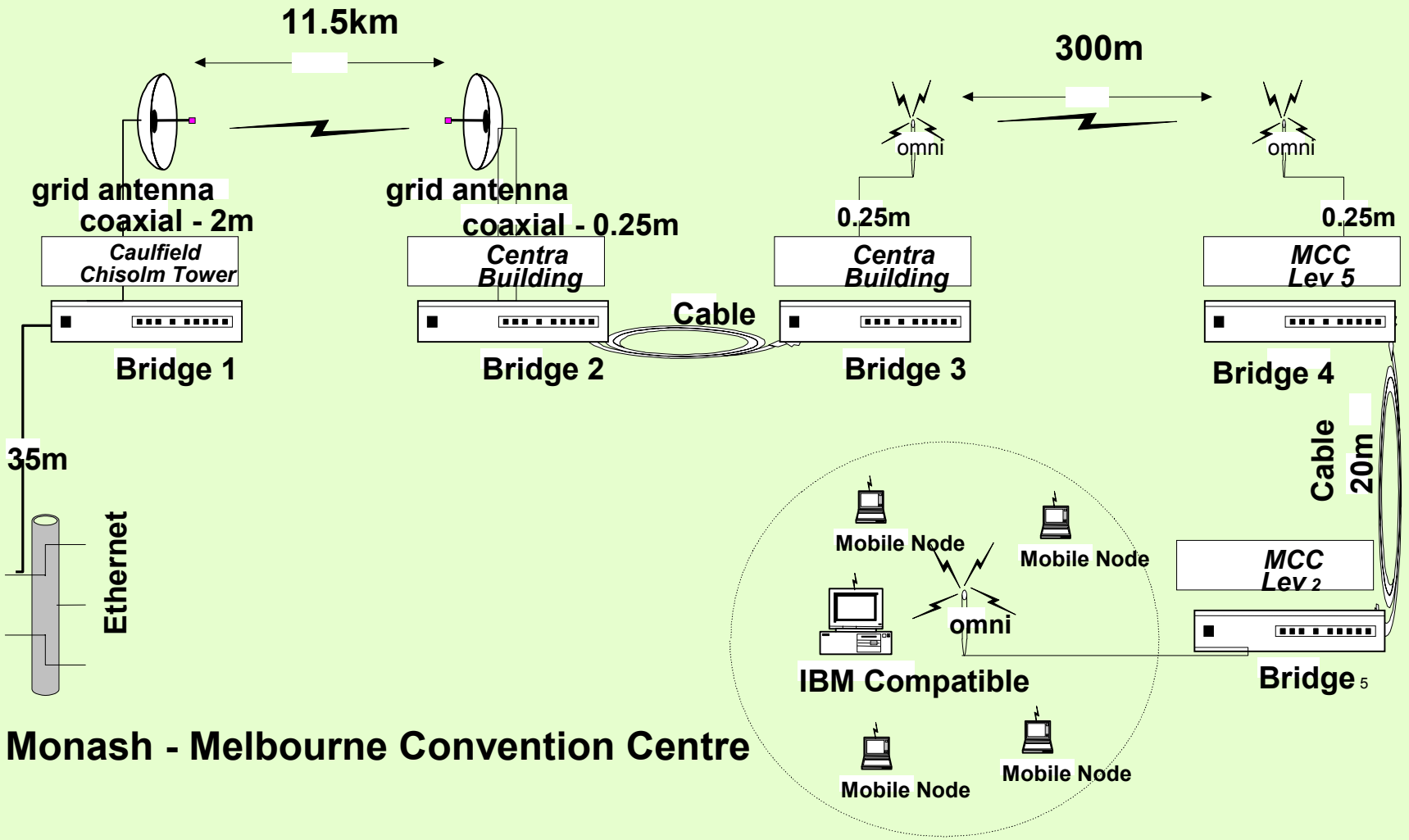


Distances Limited by 802.11 Specification

Access Point to ANY Client- Maximum Distance

Bridge to ANY Client- Maximum Distance

TOOLS'97 Conference Wireless LAN



WLAN Infrastructure

- Omni-directional
- Amplifier
- Root mode
- 10-12 km radius

- Omni-directional + grid
- Root
- 10-12 km radius
- 802.11

WLAN resources (1)

- Aironet Wireless Communications, Inc.
  - http://www.aironet.com/
- Wireless LAN Alliance Web Site
  - http://www.wlana.com
- WaveLAN Wireless Computing
  - http://www.wavelan.com/
- Wireless Data Group
  http://www.mot.com/MIMS/WDG/
- Wireless LAN Group Home Page
  - http://www.ecs.umass.edu/ece/wireless/
- Wireless LAN/MAN Modem Product Directory
  - http://hydra.carleton.ca/info/wlan.html

WLAN resources (2)

- Wireless and Mobility Products – Nortel Networks
  - http://www.nortelnetworks.com/products/wireless/
- The Wireless Web: A Directory of Industry Web Sites
  - http://www.wirelessweek.com/websites/websites.htm
- Wireless Today
  - http://www.wirelesstoday.com/links.htm

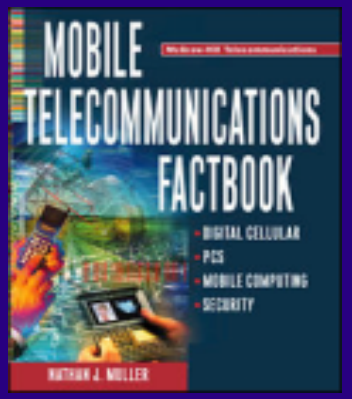
Suggested Reading

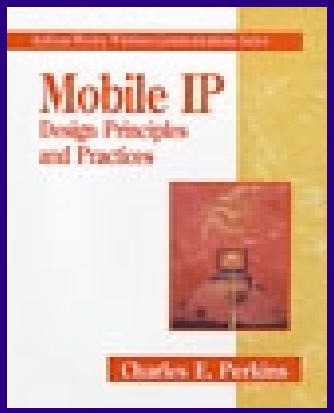
- WCCN Handbook: RF Terminals & LANs
  by Tom Polizzi
- Wireless Data Networking (Telecommunications Library)
  by Nathan J. Muller, Linda Lee Tyke (Illustrator)
- Wireless LAN Systems (The Artech House Telecommunications Library)
  by A. Santamaria, F.J. Lopez-Hernandez (Editor)
- Wireless LANs
  by Raymond P. Wenig
- Wireless Local Area Networks: Technology, Issues, and Strategies
  (McGraw-Hill Computer Communications)
  by Peter T. Davis, Craig R. McGuffin
- Wireless Networking Handbook
  by James T. Geier, Jim Geier

Suggested Reading

- Muller, N. *Mobile Telecommunications Factbook*, McGraw-Hill, 1998. ISBN 0-07-044461-7

- Mobile IP: Design Principles and Practices C. Perkins (1998) 0-201-63469-4





What have we considered ? - Technology Overview

- Wireless LANs – IEEE 802.11

What's next ?

- Bluetooth
- WAP
- GPRS & 3G
- Mobile IP